MACHINE DESIGN

February 1942

In This Issue:

Inventions and War

Shaft Vibration

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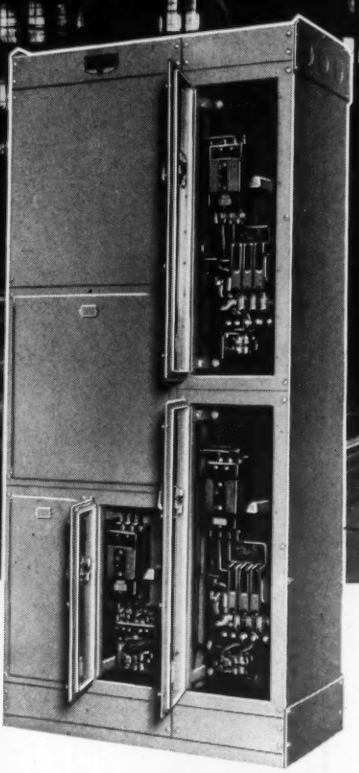

Unitrol is a *better* method of mounting, housing a *centralizing* Motor Control . . . from the individual u up to the complete plant-serving motor control center. is made up from standardized interchangeable par It is complete and usable at every step of the way. I inexpensive, speedy and easy to install, demount change. It is as "flexible as a rubber band."

The individual Unitrol *Section* hou Motor Control for several motor motorized machines, is compa space-saving, convenient and e nomical. No supports, no other structures or preparation necessary.

The individual Unitrol mounting frame is *better* for machines with built-in Motor Control. It eliminates many machining, wiring and assembling operations.

The complete Unitrol Control Center houses all the co and control equipment in the plant, for easy, spe man-power-saving installation, maintenance, cha expansion or curtailment. No wall or floor prepara No racks, trellises or frames. Permits installatio more than double as much control in same space.

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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MAIN OFFICE: The Penton Publishing Co., Penton Bldg., Cleveland, O.

BRANCH OFFICES: *New York,* 110 East 42nd St.; *Chicago,* 520 N. Michigan Ave.; *Pittsburgh,* Koppers Bldg.; *Detroit,* 6560 Cass Ave.; *Washington,* National Press Bldg.; *San Francisco,* 1100 Norwood Ave.; *London,* 2 Caxton St., Westminster, S.W.1

PUBLISHED BY The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres.; F. G. Steinebach, Secy. Published on seventh of month. Subscription in U.S. and possessions, Canada, Cuba, Mexico, Central and South America: Two years, $10; one year, $6. Single copies, 50 cents. Other countries: Two years, $14; one year, $8.

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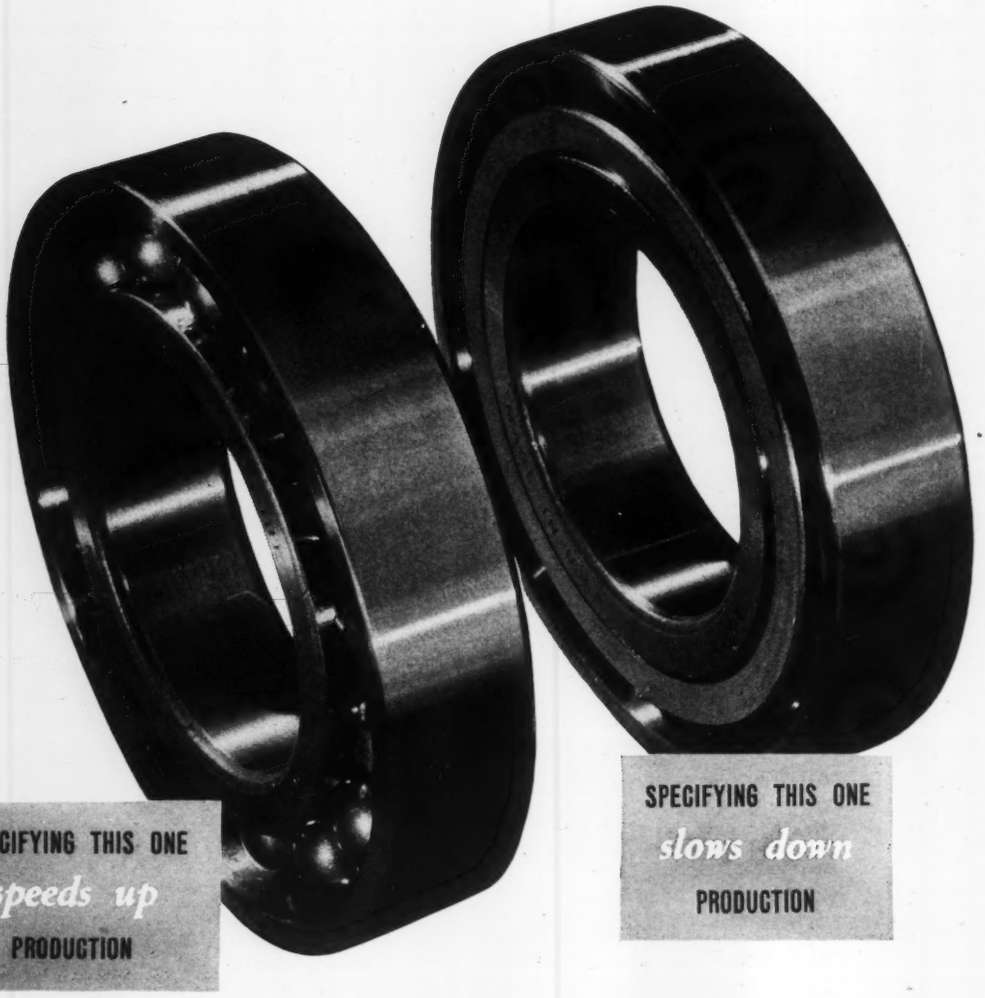
Acceptance under act of June 5, 1934, authorized July 20, 1934.

Two almost identical ball bearings



HERE are two apparently similar bearings, yet one can be produced much faster than the other. One is made to established American *standard* metric dimensions and tolerances; the other is a "special" requiring extra tooling and different machine set-ups.

Consult a New Departure engineer as to availability of types and sizes.

One "special" may well delay delivery of many *standard* bearings and the machines awaiting them, in addition to complicating the servicing of machines in the field or in the plant.

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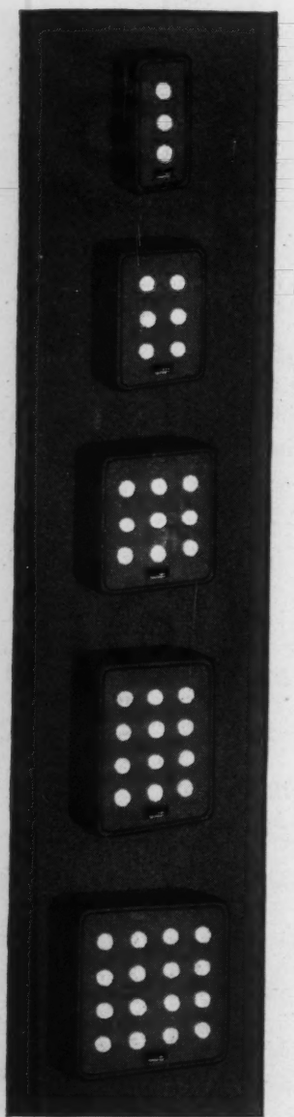

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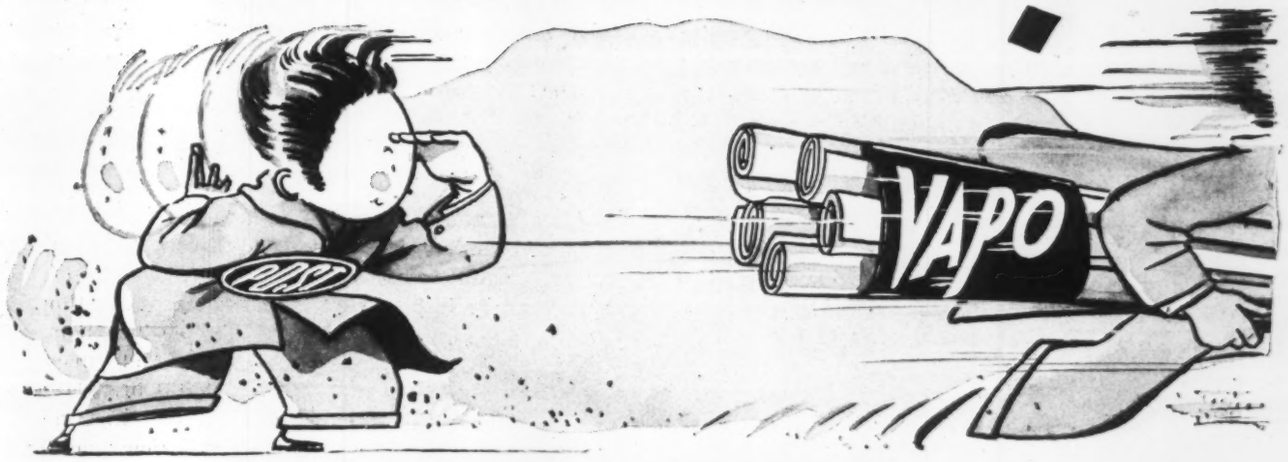

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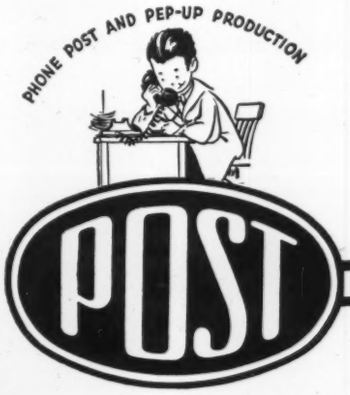

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♦

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♦

PRIMARY reason for the large scale use of diesels for military machines and marine craft is to reduce the hazards of fuel explosion. In addition to utilizing nonexplosive fuel, diesels have a 35 to 50 per cent greater range of operation with no increase in fuel load, compared with gasoline engines. According to B. B. Williams, president Cooper-Bessemer Corp., Hitler is equipping his long-range bombers with this type of power and, of the 45 war vessels built by Japan last year, 43 were diesel powered.

♦

SUCCESSFUL metal plating of acrylic plastics involves treatment with a caustic soda solution followed by treatment with a silvering solution. Subsequent electroplating gives a metallic surface to the part thus treated.

♦

SPRING steel, according to preliminary studies of steel plant metallurgists, may be utilized as armor plate by employing special heat treating methods.

TOP performance for large scale production conversion is the record set by Buick for building aircraft engines. Requiring only 200 days from blueprints to production and 243 days to finished engines, this record is representative of the speed with which automobile manufacturers have been able to swing into the tremendous war-time jobs assigned to them.

♦

COMPLEX sequential operations involved in heat treating the new one-piece cast alloy hulls and turrets for 60-ton and 29-ton tanks involves careful temperature control. Variations considered as insignificant in normal heat treating would produce nonuniform and unacceptable armor. Difficulties of meeting specifications is augmented by the fact that, for the 60-ton "fort on wheels," individual hull castings may weigh as much as 25,000 pounds and vary widely in contour and cross section. Overhead monorail conveyors above the furnaces carry the castings through the final stages of heat treatment in such a way that a minimum of conveyor mechanism passes through the heating and cooling zones.

♦

MODERN military aviators, like bombardiers, may pilot new fighters from a prone position. It is claimed that in this position the pilot is less effected by power dives than when sitting up. Visibility in a fully streamlined machine is also better.

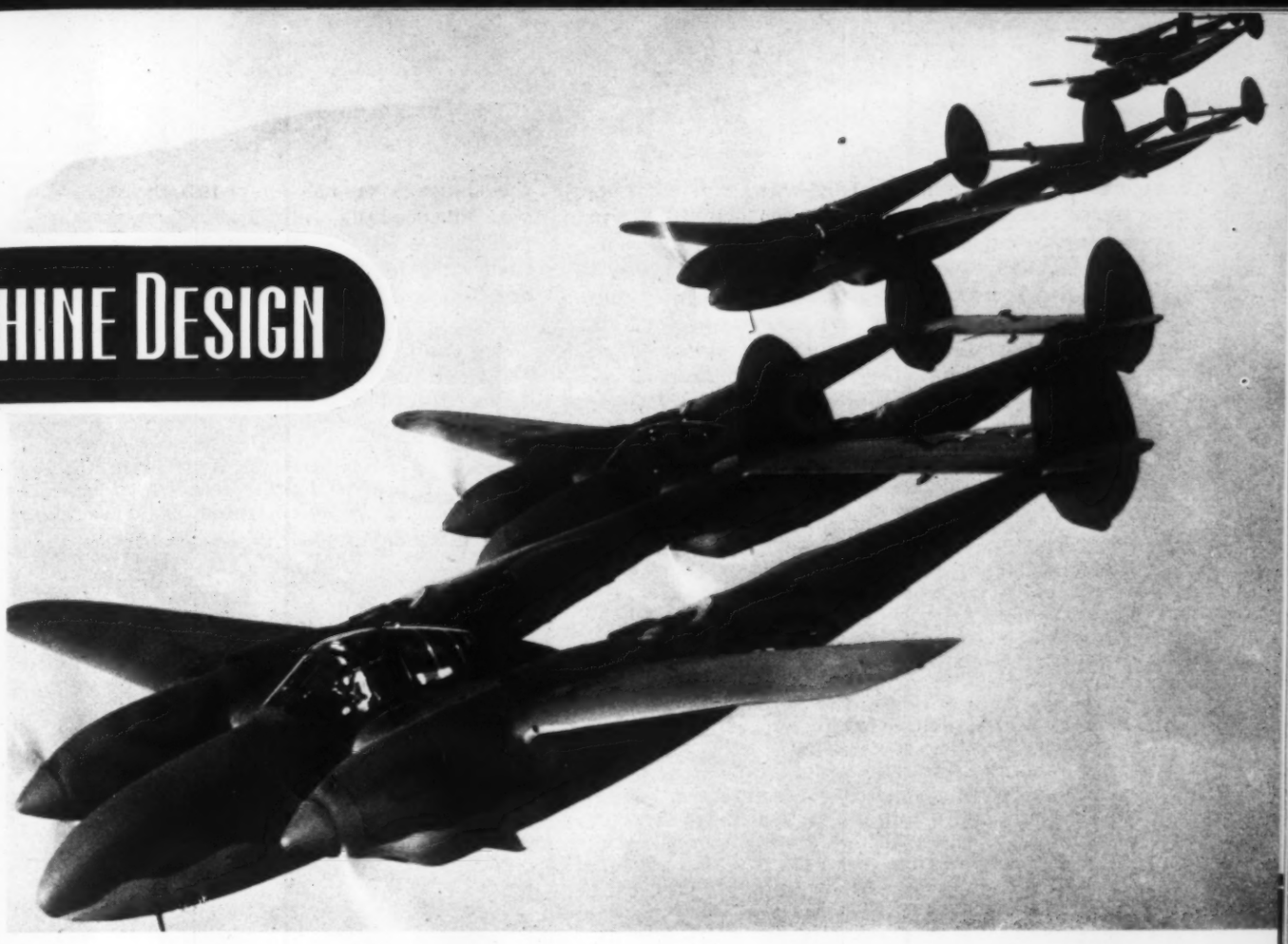
♦

AT LAST the precious metal, platinum, has more uses in industry than in jewelry which formerly held the position of first importance. With the exception of iridium, prices for platinum metals has remained practically unchanged during the past year, being about $38 an ounce.

♦

METAL foil is now being replaced by a new plastic sheet material having the appearance of metal. Vuepak a transparent cellulose acetate sheet is the base material used. The foil is three laminated sheets, the central one of which is coated with a metallic finish. This shines through the outer ones to give a metallic appearance. Reflected light gives a high gloss.

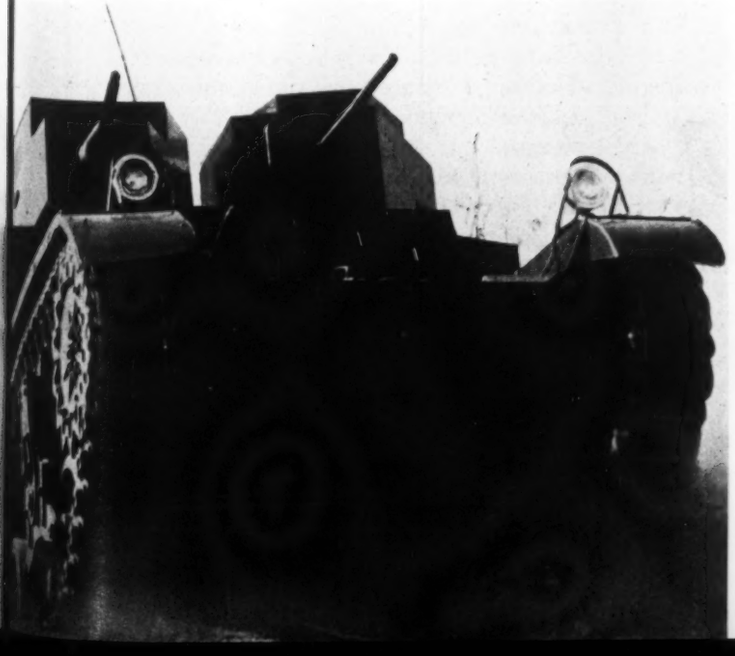
MACHINE DESIGN



Invention

War Inspires – Law Protects!

By George V. Woodling



PRESENT "all out" efforts to win the war vitally affect every phase of industrial activity. Regardless of sacrifice and cost, readjustments are being made to gear the nation to a full war-time basis. Stress, rightfully, is being placed on the importance of inventions and patents to make certain that they, too, shall be utilized to the greatest possible degree because invention and research at no time play a greater part in the service of a nation than during a war.

Importance of patents in the present enorm-

ous purchasing program of the War Department becomes readily apparent when one looks back and observes that, as a result of the last World war, approximately $600,000,000 in patent infringement suits had accumulated against the Government up to 1928. To avoid patent infringement as much as possible, the Government now has embodied in some of its purchasing contracts a "save harmless" clause. Although there are several types of such clauses, each being drafted to meet the conditions of various purchasing arrangements, the following is typical.

> "The contractor will hold and save the United States, its representatives, and all other persons acting for it as agent, contractor, or otherwise, harmless from all demands or liabilities for alleged use of any copyrighted or uncopyrighted composition, patented or unpatented invention, secret process or suggestion in, or in the making or supplying of, the articles or work herein contracted for, and for alleged use of any patented invention in using such articles or work for the purpose for which they are made or supplied. If and when required, the contractor will discharge and secure the United States from all demand or liability on account thereof by proper release from the patentees or claimants, and by bond or otherwise and to the satisfaction of the Chief of Ordnance."

Until 1910, the owner of a patent could not sue the Government for ordinary patent infringement. His only recovery was against the manufacturer who produced the alleged patented devices and sold them to the Government. By an act approved June 25, 1910, a change was made to allow a patent suit to be filed in the Court of Claims against the Government. The act in part, reads as follows:

> "Whenever an invention described in and covered by a patent of the United States shall hereafter be used by the United States without license of the owner thereof or lawful right to use the same, such owner may recover reasonable compensation for such use by suit in the Court of Claims. . . . "

Patentee May Sue Government

This act did not give the patentee the right to enjoin the Government from the use of the invention but allowed him the right to sue for reasonable compensation. Also, it did not preclude the patentee from directly suing the manufacturer that furnished the war materials to the Government. As a consequence, the owner of the patent could sue either the Government or the manufacturer, the only difference between the two suits being that as against the Government the patentee had no right of injunction whereas against the manufacturer he had a right of injunction to prevent manufacture and sale. Thus, by suing the manufacturer, the patentee could indirectly prevent the Government from buying the goods. To overcome the stoppage of war materials, the Act of 1910 was amended on July 1, 1918, to require the patentee to sue the Government in the Court of Claims for his entire compensation. The changes are italicized below to show the amended act.

> "Whenever an invention described in and covered by a patent of the United States shall hereafter be used or *manufactured* by *or for* the United States without license of the owner thereof or lawful right to use or manufacture the same, such *owner's remedy shall be by suit against the United States* in the Court of Claims *for the recovery of his reasonable and entire compensation for such use and manufacture.* . . . "

The amended act frees the manufacturer from liability in dealing with the Government. No right of injunction can be issued against the manufacturer to stop the flow of war materials. Therefore, since the Government cannot be enjoined from using the patented invention but can only be sued for compensation, and the manufacturer cannot be sued at all for furnishing the patented invention to the Government, the patentee cannot by injunction prevent the Government from infringing the patent. Consequently, the Government cannot be stopped by a patent.

In a suit, the Government is entitled to all the defenses ordinarily available to a manufacturing defendant. Thus its opportunity of winning a suit is as favorable as that of the manufacturer. *Figs.* 1, 2 and 3 illustrate typical war-time inventions for which suits were filed after the World war.

Manufacturer Is Liable

Although the "save harmless" clauses in the present Government contracts might appear to take away any right of the patentee to sue the Government for reasonable compensation, they do not so operate. In fact, if the patentee is to sue at all he must sue the Government, but the manufacturer in such suit is contractually bound to repay the Government for any loss sustained in the infringement suit. The practical effect of the save harmless clauses is to enforce the manufacturers of war materials to acquire patent licenses under adversely held patents. As another alternative, the manufacturer is induced to develop and patent articles of his own engineering design.

Another aspect of inventions and patents in national defense deals with the problem of preventing the enemy from securing technical and engineering information regarding our war machines and other defense weapons. To carry out this purpose, Congress passed a bill (Public No. 700, approved by the President, July 1, 1940) providing for the secrecy of inventions. Upon the passage of this law, the Commissioner of Patents may withhold the publication or grant of a patent for such period or periods as in his opinion the

national interest requires. The law reads:

"Whenever the publication or disclosure of an invention by the granting of a patent might, in the opinion of the Commissioner of Patents, be detrimental to the public safety or defense he may order that the invention be kept secret and withhold the grant of a patent for such period or periods as in his opinion the national interest requires: Provided, that the invention disclosed in the application for said patent may be held abandoned upon it being established before or by the commissioner that in violation of said order said invention has been published or

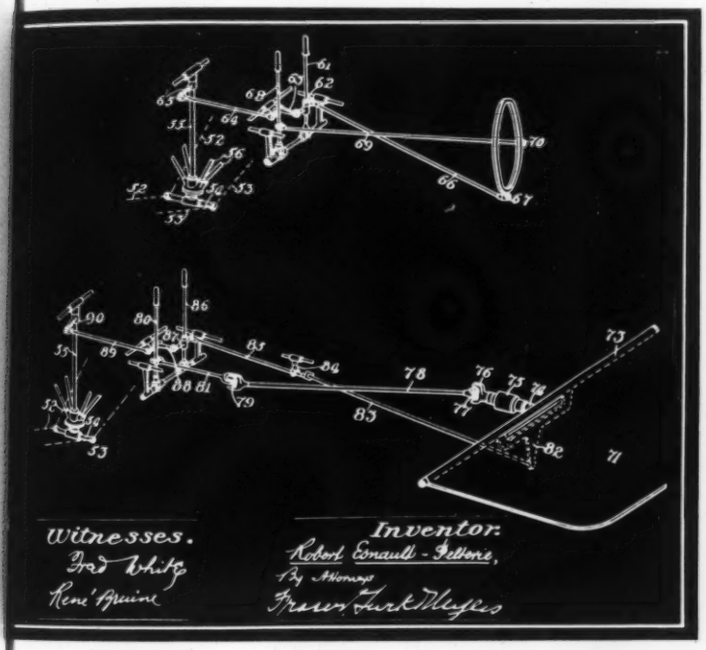


Fig. 1—Original patent drawing of "joy stick" for airplanes. Supreme Court held in a decision after the first World war that compensation was due the inventor from the Government

disclosed or that an application for a patent therefor has been filed in a foreign country by the inventor or his assigns or legal representatives, without the consent or approval of the Commissioner of Patents.

"When an applicant whose patent is withheld as herein provided and who faithfully obeys the order of the Commissioner of Patents above referred to shall tender his invention to the Government of the United States for its use, he shall, if and when he ultimately receives a patent, have the right to sue for compensation in the Court of Claims, such right to compensation to begin from the date of the use of the invention by the Government: Provided, that the Secretary of War or the Secretary of the Navy or the chief officer of any established defense agency of the United States, as the case may be, is authorized to enter into an agreement with the said applicant in full settlement and compromise for the damage accruing to him by reason of the order of secrecy, and for the use of the invention by the Government.

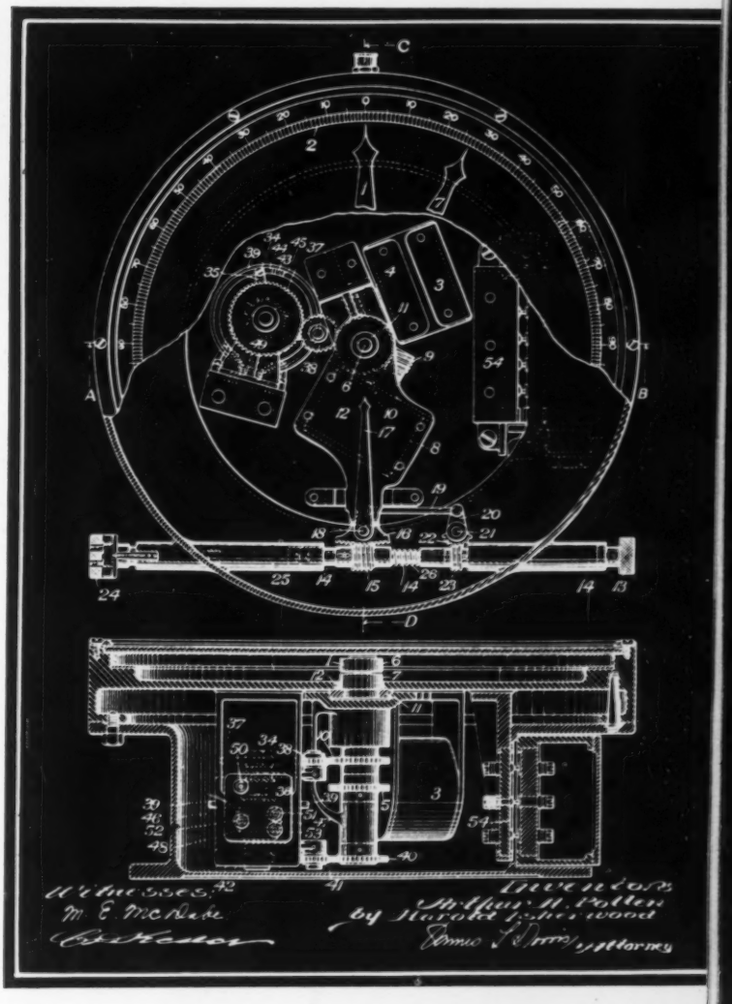
Violation of the secrecy law or failure to keep the invention a secret may forfeit patent rights.

During the previous World war, under the authority of a similar secrecy law (Act of October 6, 1917), the examination of patent applications was done by officers of the army and navy.

Under the present law, the selection of the applications which are to be covered by the secrecy order is done by the Patent Office defense committee comprising members selected from the Patent Office staff. Under the procedure of the committee, each primary examiner in the Patent Office is required to examine the applications under his charge to determine which in his opinion should be placed under a secrecy order. These applications are reviewed by the defense committee. Those selected by the committee are then submitted to the war and navy department through members of a joint army and navy patent advisory board.

When an application is recommended for secrecy by the board, the secrecy order may be issued by the Commissioner of Patents. The order does not

Fig. 2—Naval fire control invention for which patentee sued. Case was dismissed by court



affect the usual examination of the application in the Patent Office. Prosecution continues in the regular manner until the application is ready for allowance. At this point everything is held in abeyance. The application then will be held from issue during such period or periods as the national interest requires. The fact that an application is placed under an order of secrecy is no indication that the government intends to use the invention nor is it an indication that the invention is a meritorious one. To allay the anxiety of an applicant who might be led to believe that his application is valuable, the order contains the following:

> "This order should not be construed in any way to mean that the Government has adopted or contemplates adoption of the alleged invention disclosed in this application, nor is it any indication of the value of such invention. It is recommended that you tender this invention to the Government of the United States by communicating directly with the (War or Navy) Department."

Should the Government use the invention, the inventor must look to it for compensation. If the Government declines to use the invention, the inventor may desire to approach a manufacturer for exploitation. He should first, however, petition the commissioner of patents for a release from secrecy for that specific purpose. If no relief is obtained and the applicant in violation of the law discloses the invention to others, he risks losing the ultimate right to his patent.

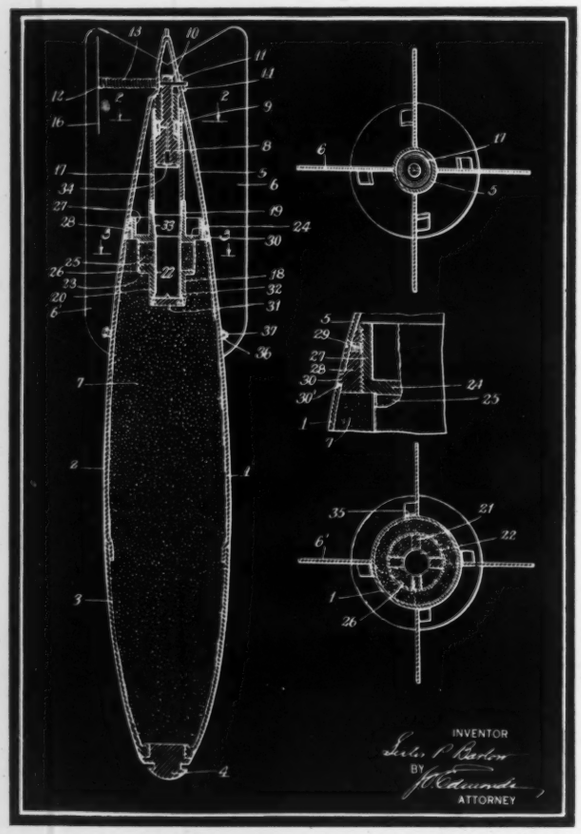


Fig. 3—Contact bomb design for which compensation was justly due the inventor as held by the Court of Claims

The Secrecy Act as originally passed did not provide for penalties for violation thereof but only specified that the invention would be held abandoned. By amendment (effective September 21, 1941), the act was changed to include a penalty providing a fine of not more than $10,000 or imprisonment for not more than two years, or both. The amendment also specified that no foreign application could be filed without first obtaining a license to do so from the Commissioner of Patents. The portion of the amendment dealing with the filing of applications in foreign countries is principally covered in Section 3, which reads:

> "No person shall file or cause or authorize to be filed in any foreign country an application for patent or for the registration of a utility model, industrial design, or model in respect of any invention made in the United States, except when authorized in each case by a license obtained from the Commissioner of Patents under such rules and regulations as he shall prescribe."

The actual papers which are to be sent to the foreign country must accompany the petition in an unsealed envelope. The petition identifies the United States application forming the basis for the foreign application, as well as states whether or not a secrecy order has been placed upon the application. If filing abroad is approved, the unsealed envelope containing the foreign patent papers is then sealed and returned to the applicant, together with the license. The sealed envelope may then be mailed upon submitting the license therefor to the Post Office.

Council Aids Development

Another phase of inventions and patents in national defense deals with the activities of the National Inventors Council created by the Secretary of Commerce with Charles F. Kettering as its chairman. The council appears to have a dual function. In one capacity it functions as a clearing house for inventions and suggestions from civilians relating to national defense. The council will consider an invention regardless of whether or not an application has been filed in the Patent Office.

As a second function, the council co-operates closely with the army and navy and endeavors to solve specific problems. To solve these problems the council has identified with it many able inventors of specialized training and experience. The council is not authorized to purchase inventions from civilians nor does it have any available money to spend for actual working or development of the inventions through experimental work, although it will help inventors as much as possible to dispose of their inventions. For an inventor to

protect his interest, he should file an application for a patent. Should a secrecy order be placed upon the application, he may submit the same to the Government under the provisions of the secrecy order previously discussed.

As a separate organization from the National Inventors Council, a National Defense Research Committee, under the chairmanship of Dr. Vanevar Bush, operates to co-ordinate research and experimental activities of the many engineering laboratories throughout the country and to concentrate their efforts toward the development of special guns, tanks and other war-time mechanisms. Through this action, duplication of research development is reduced to a minimum and special inventive talent is applied to the making of worthwhile inventions for the army and navy.

The wholesome atmosphere of encouraging civilians as well as directing specialized technical experts to solve particular problems by the application of inventive skill will hasten our efforts to win the war. Growth of new inventions in the next few years will probably follow the same pattern or curve as shown in *Fig.* 4 which illustrates the rapid rise in the number of patent applications filed in the Patent Office after the last war.

Prospective curve for the number of applications to be filed during the period immediately following the termination of this war will probably rise at a faster rate for the reason that patent applications must now (since August 5, 1940) be filed within *one* year after the public use thereof in order to secure a valid patent, whereas *two* years were permitted previously.

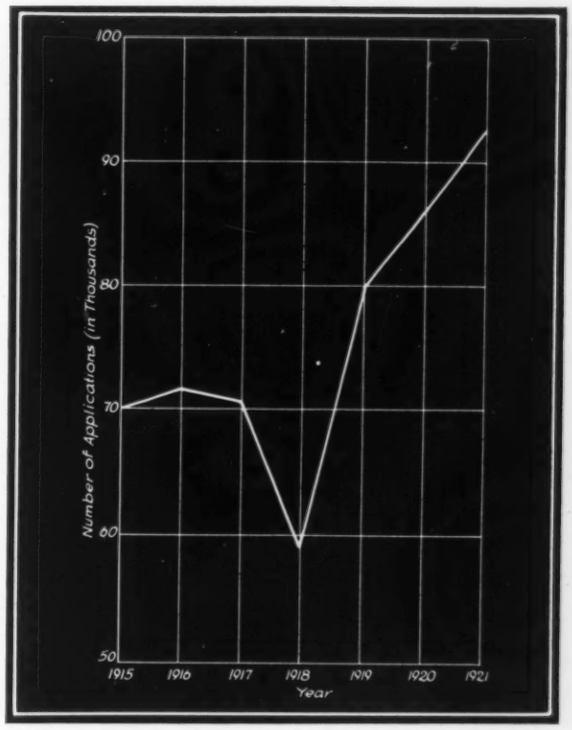


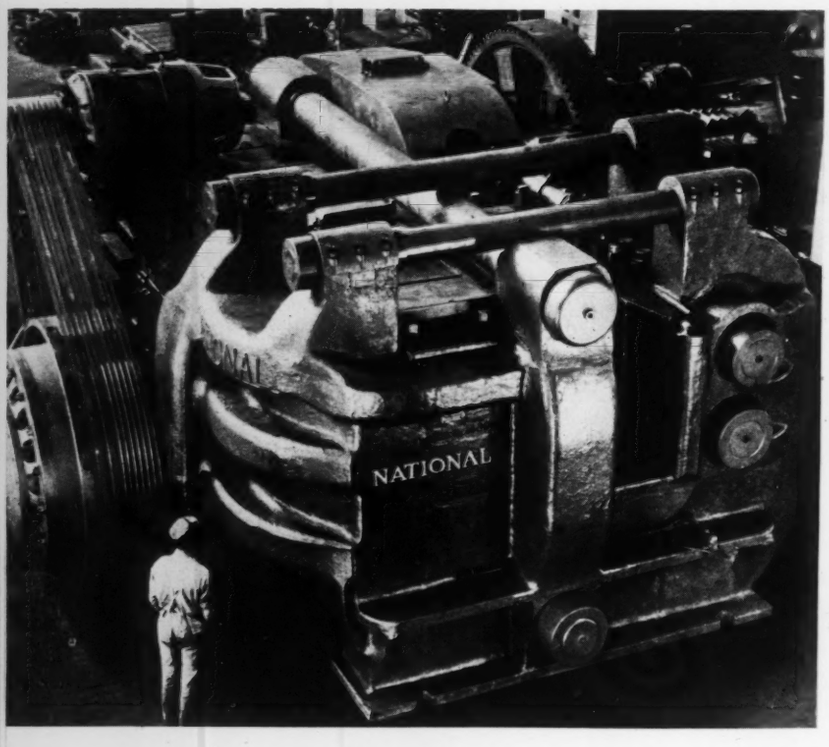
Fig. 4—Patent applications filed during 1915 to 1921 showing rapid rise after the World war. Even more phenomenal increase is predicted after present war

Will Benefit Nation

Creation of these inventions will greatly benefit our nation as a whole in the years ahead. To make certain that inventions and patents will be used to the greatest possible benefit, President Roosevelt has established the National Patent Planning Commission (Executive Order No. 8977, December 12, 1941) consisting of five members to be appointed by the President. The purpose of this commission may best be understood by reference to the order itself, which reads in part:

> "Whereas both American industrial development and our people generally have greatly benefited by the products of American inventive genius;
>
> "And whereas it is essential even in time of war to plan for a full utilization of the nation's expanded industrial capacity with the return of peace, a problem to which the inventive genius of our citizens can be applied at this time and which also requires a study to be made of our existing patent laws and procedure, together with other appropriate action, by a commission familiar with the problems of science, industry, agriculture, labor and the consumer;
>
> "Now, therefore, by virtue of the authority vested in me as President of the United States, I do hereby order as follows:
>
> 1: There is hereby established the National Patent Planning Commission consisting of five members to be appointed by the President.
>
> 2: The Commission is authorized, in conjunction with the Department of Commerce, to conduct a comprehensive survey and study of the American patent system, and consider whether the system now provides the maximum service in stimulating the inventive genius of our people in evolving inventions and in furthering their prompt utilization for the public good; whether our patent system should perform a more active function in inventive development; whether there are obstructions in our existing system of patent laws, and if so, how they can be eliminated; to what extent the Government should go in stimulating inventive effort in normal times; and what methods and plans might be developed to promote inventions and discoveries which will increase commerce, provide employment, and fully utilize expanded defense industrial facilities during normal times . . . .
>
> 5: The Commissioner of Patents and his office will assist the Commission, which is also authorized to call upon other offices and agencies of the Government for such aid and information as may be deemed necessary for its work.
>
> 6: The Commission shall report the results of such investigations and studies to the President, together with recommendations.

Scanning the Field for

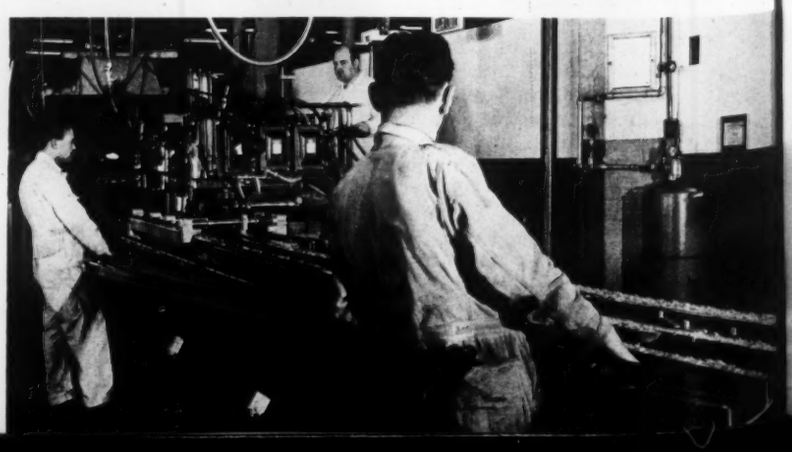


Stiffness and rigidity are achieved in this compact forging machine, left, recently installed at Tube Turns, Inc., chiefly because the flywheel shaft is mounted in the neutral axis of the bed frame and the overarm heading slide permits locating the main shaft further forward without sacrificing tool alignment. Best utilization of bed frame weight reduces "spring" to achieve accuracy in work.

To provide speed as well as precision, heading and gripping slides have wedge adjustment. Longitudinal and cross tie-bars are adequately heavy. Protection against accident is provided by a tandem by-pass automatic grip relief and a friction-slip flywheel. Clutch is operated by air which is admitted at the center of the plates. These are self-aligning and are not required to serve the double purpose of a driving means and a friction relief on the heading movement.

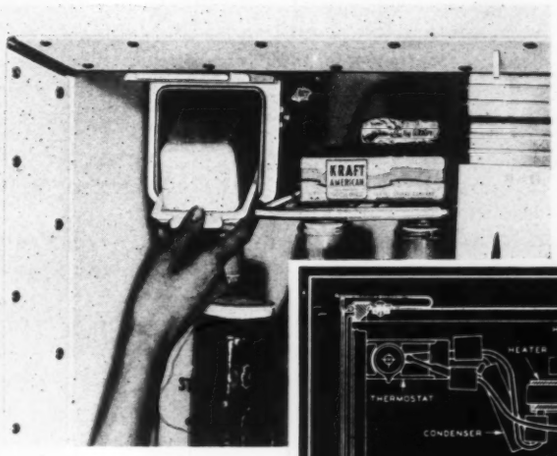
Multiple operation on the high-cycle milling machine at right effects a savings of 3½-days production time on each "Lightning" P-38 Interceptor built by Lockheed Aircraft Previously, milling of long extrusions on tapers with cutouts in flanges and various other cuts for weight reduction involved considerable expense.

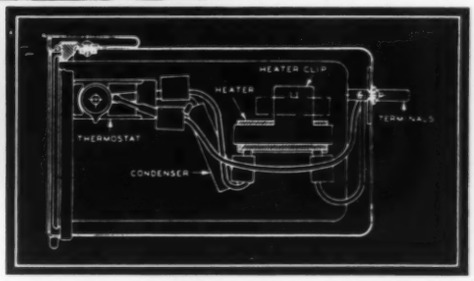
Thirty feet in length with a cutting area of one foot in width and twenty feet in length, the machine employs a carriage which travels on its ways by rack and gear. Channel extrusions are held by cam and dog air clamps in a steel fixture with former bars attached. Machined on one surface, each former bar guides the cutter heads by a cam and roller. Carriage feed is adjusted by a hydraulically controlled variable-speed unit. In motion, the carriage trips a bell crank which in turn operates the air cylinders controlling the variable-speed unit. For parts impractical to clamp with air, a carriage with spring-tensioned rollers is utilized to hold the parts uniformly and securely.



Polaroid screens for indicator lights in the cockpit of airplanes reduces both bulk and weight over designs employing resistors, as well as giving the pilot more easily controlled light. Considering that often more than a score of these lights are used on a control panel, the saving becomes a worthwhile factor. Designed by Westinghouse, the lamp unit at right is a self-contained compact unit, adjustable to conditions of darkness by rotating the knurled ring.

Two concentric layers of polarizing screens are placed between the lamp and lens, one being fixed and the other adjustable. The stationary screen polarizes the light in the horizontal plane while the position of the other controls the amount of light transmitted. Thus the pilot can obtain any brilliance desired.

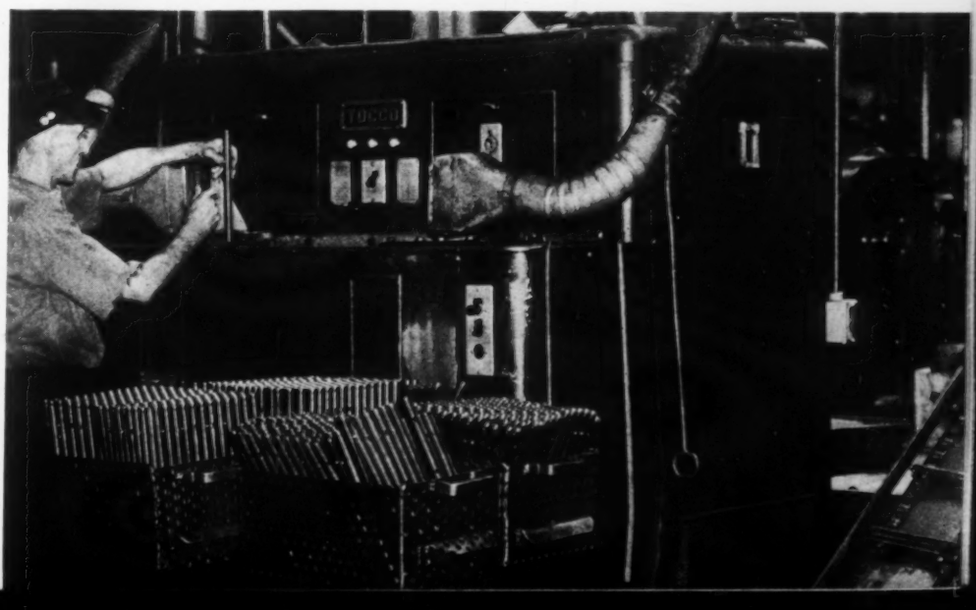




Heat-controlled cooling for a refrigerator butter compartment proves simpler and more economical than direct control with an auxiliary evaporator system. Shown at left is a compartment arrangement for General Electric refrigerators where electrical energy maintains the correct temperature, which is always higher than that of the refrigerator. Average energy consumption is about 1½ kilowatt-hours a month. Alternative method of using a multiplex refrigerating system with separate evaporator and controls would be many times more costly and, in addition, would not operate as satisfactorily. Thus it is not practical to complicate the refrigerating mechanism when a small electrical heater as shown in the schematic diagram can do the job so simply and with an insignificant amount of energy.

Obviating copper bushings by hardening shafts is but one step in the important program of conserving materials and reducing assembly costs. Shown at left is an induction hardening process utilized in one plant for hardening rocker arm shafts to 50 Rockwell C so that the bearing material does not cause wear on the shafts. In this way forgings, cast iron and malleable iron can be drilled direct for bearings, eliminating the usual softer bushings.

In this machine, shafts are hardened six at a time to produce 12,000 units daily. Because of the speed of the process no surface oxidation occurs. Neither is there any grain growth of the unhardened core. Distortion is negligible, so only finish grinding and lapping are performed on the shafts.



Applying Mobility Method to St

By R. C. Binder

Associate Prof. of Mechanical Engineering
Purdue University

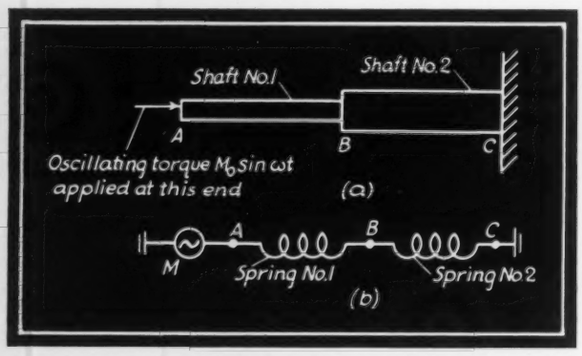
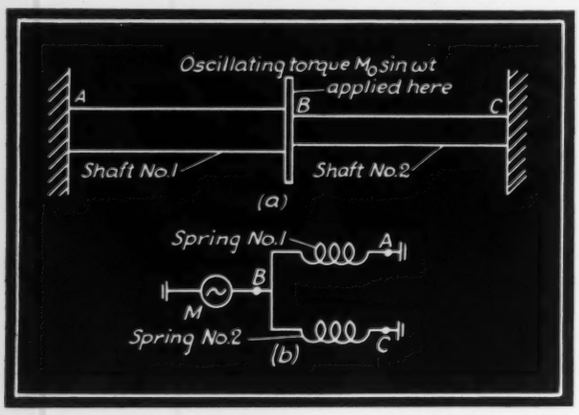


Fig. 1—Series connection of mechanical elements is illustrated by cantilever shafts and schematic diagram. Each shaft is treated as a torsion spring

Fig. 2—Parallel connection of mechanical elements and its schematic diagram afford a contrast to the series connection in Fig. 1



STUDY of torsional vibrations in gear systems may become so involved that a serious consideration of the method of analysis is warranted. Methods employing differential equations and dynamically equivalent systems are well known. The electrical analogy might be considered because of a possible advantage in using adequate symbols and circuit diagrams. Another possible method of approach involves an application of the "mobility method" developed by F. A. Firestone.*

Purpose of this article is to outline the vibration analysis for gear systems by using the mobility method. This is a direct method of study, not an analogy. It does not require differential equations and is particularly useful and enlightening in numerical computations for complicated systems of gears.

In the development of the method the following assumptions are made:

(a) Masses, springs and resistors are each concentrated or "lumped"

(b) Each spring torque (as in a shaft or coupling) is directly proportional to the angular displacement

(c) Attention is limited to forced or free vibrations in normal modes

(d) Any frictional resistance is directly proportional to the velocity. This assumption is reasonable for conditions of perfect lubrication, for cases in which a body is damped by a dashpot, and for cases in which a body moves through a viscous fluid. This assumption does not apply for cases of friction between dry surfaces.

A mechanical element such as a spring, mass or resistor is regarded as "pure". All important properties of a mechanical structure are taken into account by breaking up the structure into separate pure elements. For example, if a shaft in torsion has appreciable mass, it would be considered as the combination of two separate elements, a mass and a spring.

Mobility Expressed as Complex Number

Considering simple harmonic action, and using complex numbers, the relations in TABLE I apply. This notation is used because it is convenient and compact ($\theta = \theta_0 \epsilon^{j\omega t} = \theta_0 \cos \omega t + j\theta_0 \sin \omega t$). The real part of θ is $\theta_0 \cos \omega t$ and represents a simple harmonic motion having a displacement amplitude θ_0 and a circular frequency ω.

The mobility (ease of motion) Z of an element (or a group of elements) is a complex number. The absolute value of this complex number is the amount of angular velocity produced by unit torque. The

* "The Mobility Method of Computing the Vibration of Linear Mechanical and Acoustical Systems: Mechanical-Electrical Analogies"—F. A. Firestone, *Journal of Applied Physics*, Vol. 9, No. 6, June, 1938, Page 373.

Vibration

angle of the number is the angle by which the angular velocity leads the torque. Mobility of each of the three mechanical elements is given in TABLE II. Also, the conventions used in drawing diagrams are shown in TABLE III.

A "torque vibrator" will impress a given torque amplitude on any mechanical system to which it may be connected, regardless of the mobility of that system. An "angular velocity vibrator" will impress a given angular velocity amplitude on any mechanical system to which it may be connected, regardless of the mobility of that system.

Series, Parallel Connections Defined

Mechanical elements are connected in "series" when their terminals are connected end to end with no more than two terminals to any junction point. Functionally, a series connection results in the same torque acting through all the elements, while the total angular velocity across the combination is the sum of the velocities across the individual elements.

Fig. 1*a* shows a series connection of two massless shafts. An oscillating torque is applied at end *A*, while end *C* is fixed. The schematic diagram is shown in *Fig.* 1*b*. Points *A*, *B*, and *C* in *Fig.* 1*a* correspond to points *A*, *B* and *C*, respectively, in *Fig.* 1*b*. At any time during the vibration the torque through the combination of shafts equals the applied torque. The angular velocity across spring *AB* (velocity of *A* with respect to *B*) plus the velocity across spring *BC* equals the angular velocity across the combination.

Elements are connected in "parallel" when their terminals are connected to common junction points as indicated in *Fig.* 2. Functionally, a parallel connection results in the same angular velocity across all the elements, while the torque through the combination is the sum of the torques through the individual elements. In *Fig.* 2 the angular velocity of the right end of shaft 1 equals the velocity of the left end of shaft 2. The torque through shaft 1 plus the torque through shaft 2 equals the applied torque.

Each mechanical element has two terminals. Resistors could be illustrated in the same way as were springs in the above discussion. For a mass element one terminal is some point on the mass itself, while the other terminal is the fixed frame or ground relative to which is measured the velocity of the mass.

Mobility of a series combination of elements is

$$Z = Z_1 + Z_2 + Z_3 + \ldots\ldots\ldots\ldots\ldots$$

Mobility of a parallel combination is

$$Z = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \ldots\ldots\ldots}$$

The mobility method involves drawing the schematic diagram of the mechanical system and applying the above simple relations. Mobility of the combination through which the given oscillating torque is applied can then be computed. Mobility of any vibrating mass and the system to which it is connected is infinite at a natural frequency.

TABLE I

Properties of Mechanical Elements

Property	Instantaneous Value	Amplitude
Angular displacement	$\theta = \theta_0 \epsilon^{j\omega t}$	θ_0
Angular velocity	$\phi = \phi_0 \epsilon^{j\omega t}$	$\phi_0 = j\omega\theta_0$
Angular acceleration	$\alpha = \alpha_0 \epsilon^{j\omega t}$	$\alpha_0 = j\omega\phi_0 = -\omega^2\theta_0$
Torque	$M = M_0 \epsilon^{j\omega t}$	M_0

As an illustration, *Fig.* 3*a* shows a disk of moment of inertia, *I*, attached to a vertical shaft of torsional compliance *l*. Neglecting damping, consider the twisting motion of the disk under the effect of an externally applied torque $M_0 \sin \omega t$. Application of the mobility method gives the schematic diagram *Fig.* 3*b*. The elements are shown in parallel because one terminal of each is the fixed frame and the other terminals are fastened together.

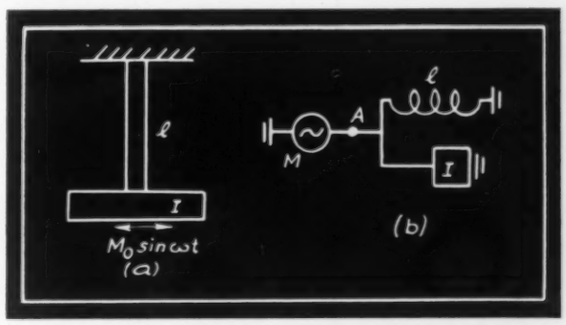


Fig. 3 —Above — Undamped torison pendulum exemplifies a combination of series, parallel connections

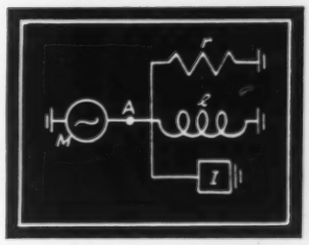


Fig. 4 — Right — Damping or resistance element added to the schematic diagram of Fig. 3

Mobility of point *A*, *Fig.* 3*b*, is computed on the

basis of a parallel system of elements,

$$Z_A = \frac{1}{\frac{1}{j\omega l} - \frac{\omega I}{j}} = \frac{j}{\frac{1}{\omega l} - \omega I} \quad \ldots\ldots (1)$$

The natural frequency ω_c is determined by making Z_A approach infinity. Then

$$\omega_c = \sqrt{\frac{1}{Il}} \text{ radians per second}$$

$$f_c = \frac{1}{2\pi}\sqrt{\frac{1}{Il}} \text{ cycles per second} \quad \ldots\ldots (2)$$

If K is taken as the torsional spring constant of the shaft, $l = 1/K$ and Equation 2 takes the familiar form $\omega_c = \sqrt{K/I}$.

For a circular shaft of length L and diameter d

$$l = \frac{32\,L}{\pi d^4 G} \quad \ldots\ldots (3)$$

For a circular disk of uniform thickness, diameter D and weight W

$$I = \frac{WD^2}{8\,g} \quad \ldots\ldots (4)$$

Consider the numerical case in which the disk weight is 1000 pounds, disk diameter is 50 inches, length of shaft 120 inches, shaft diameter 4 inches,

TABLE II
Mobility of Elements

Spring	$Z = j\omega l$
Resistor	$Z = r$
Mass	$Z = -\frac{j}{\omega I}$

and $G = 11.5 \times 10^6$ pounds per square inch. Application of Equations 2, 3 and 4 gives $f_c = 8.7$ cycles per second as the natural frequency of torsional vibration.

Function of Angular Velocity

For the general case, the angular velocity amplitude of the disk follows directly from the relation

$$\phi_0 = M_0 Z_A = \frac{M_0 j}{\frac{1}{\omega l} - \omega I} \quad \ldots\ldots (5)$$

Angular displacement amplitude of the disk is $\theta_0 = \phi_0/j\omega$. The familiar resonance curves are obtained if the absolute values θ_0 and ϕ_0 are plotted against the frequency of the impressed torque.

Fig. 4 shows the schematic diagram if a damping torque is to be included. It is assumed that the damping torque equals some constant C times the angular velocity. The responsiveness, r, of the resistor is the reciprocal of C.

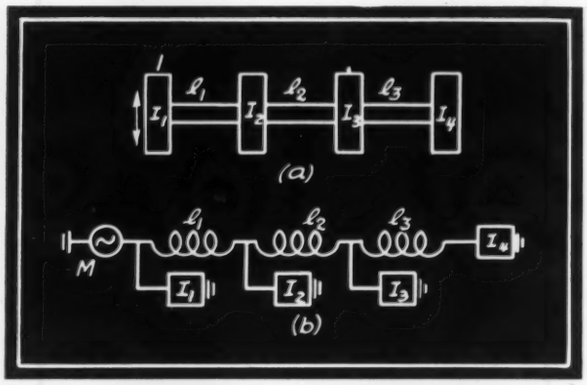


Fig. 5—Gears or masses fastened at intervals on a single shaft are handled schematically according to the lower diagram

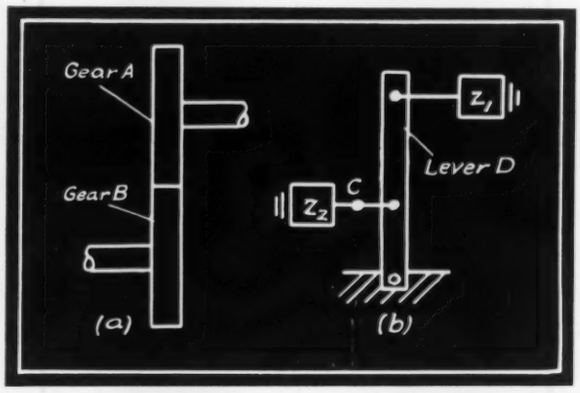


Fig. 6—Lever analogy for gear systems is used in constructing the schematic diagram for intermeshing gears on parallel shafts

With damping,

$$Z_A = \frac{1}{\frac{1}{j\omega l} - \frac{\omega I}{j} + \frac{1}{r}} \quad \ldots\ldots (6)$$

The effect of frictional resistance can be demonstrated easily by means of Equation 6.

Various combinations of elements can be analyzed in this fashion. The displacement, velocity and acceleration at any point, and the natural frequencies can be calculated directly by means of algebraic equations.

Assumes Sinusoidal Torque

Fig. 5*a* represents a shaft with a set of gears or masses (as in a transmission). Assume that a sinusoidal torque is applied to mass 1. *Fig.* 5*b* gives the schematic diagram. The normal elastic curve can be plotted from computations of the angular displacement amplitude of each mass.

In *Fig.* 6*a*, gear A is connected to a system of mechanical elements on the right. Z_1 equals the mobility of the system on the right, including gear A.

Z_c refers to the mobility of the combination of elements on the left, including gear B. Assume that the gears are rigid (no elastic deformation), that the tooth surfaces are perfect, that there is no backlash, and that friction between the gear teeth can be neglected. The force transfer at the pitch point of the gears is instantaneous; likewise the motion transfer at the pitch point. Then gear contact involves no change in the angle of mobility, that is, the angle by which the angular velocity leads the torque. There may be a change in the absolute value of the mobility, depending upon the gear ratio. The massless, springless and resistanceless lever D in *Fig. 6b* may be employed to represent this change in the absolute magnitudes of angular velocity and torque.

Let the gear ratio (speed of B/speed of A) $= n$. Referring to *Fig. 6b*, then $\phi_c = n\phi_1$, and $M_c = M_1/n$. Thus the mobility at point $C = Z_c = n^2 Z_1$. The absolute value of the mobility is changed by the square of the gear ratio. Each gear contact in a system of numerous gears can be treated in this manner. Further, there is no restriction placed on the type of gears.

As an example, refer to the gear system indicated in *Fig. 7a*. Let

$$Z_1 = -\frac{j}{\omega I_1} \qquad Z_4 = -\frac{j}{\omega I_4}$$

$$Z_2 = j\omega l_2 \qquad Z_5 = j\omega l_5$$

$$Z_3 = -\frac{j}{\omega I_3} \qquad Z_6 = -\frac{j}{\omega I_6}$$

$$n = \frac{\text{speed of gear 3}}{\text{speed of gear 4}}$$

Assume that a sinusoidal torque $M = M_0 \sin \omega t$ acts on mass 1

Referring to *Fig. 7b*, the mobility of point A, looking toward the right, is

$$Z_A = \frac{1}{\frac{1}{Z_4} + \frac{1}{Z_5 + Z_6}}$$

Mobility of point B is $Z_B = n^2 Z_A$. Continuing, the mobility at point E becomes the continued fraction

$$Z_E = \cfrac{1}{\frac{1}{Z_1} + \cfrac{1}{Z_2 + \cfrac{1}{\frac{1}{Z_3} + \cfrac{1}{\cfrac{n^2}{\frac{1}{Z_4} + \frac{1}{Z_5 + Z_6}}}}}}$$

The mobility Z_E of point E is the angular velocity which unit torque would produce at point E. If the impressed torque, M, and the vibration frequency is known, the angular velocity of point E can be found directly from the relation $\phi_E = Z_E M$. The torque, angular velocity and angular displacement amplitudes at all points in the system can be found by continuing through successive junctions.

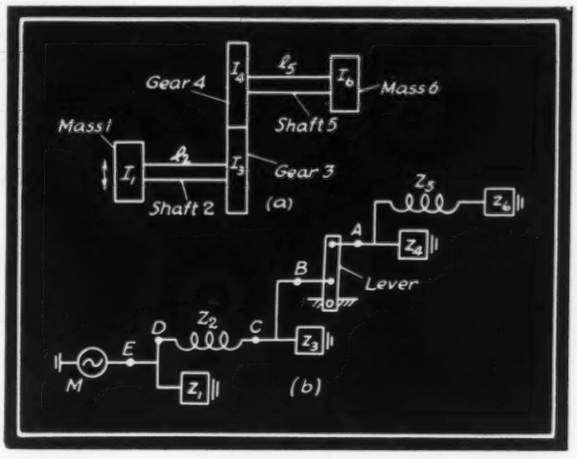


Fig. 7—If perfect tooth profiles and gear action are assumed, schematic diagram is drawn as shown

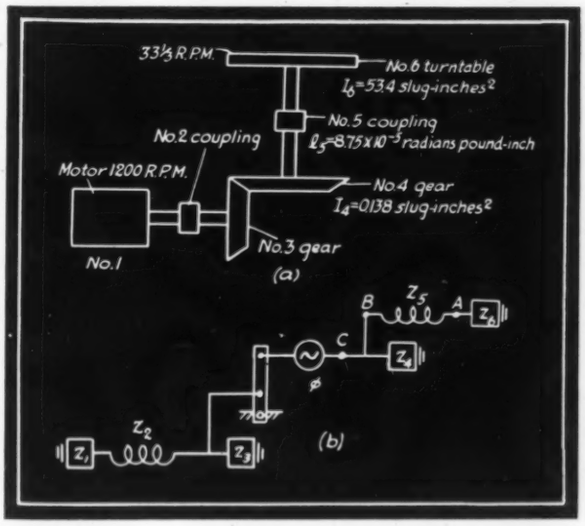


Fig. 8—Schematic diagram for turntable drive is constructed assuming gear tooth irregularities

How to Obtain Natural Frequency

For instance, the velocity of point D is the same as that of point E (angular velocity of mass 1 is the same as that of the left end of shaft 2). Knowing ϕ_D and Z_D, the torque through shaft 2 can be computed ($M_D = \phi_D/Z_D$). The torque at D (left end of shaft 2) equals the torque at C (right end). Knowing M_c and Z_c, the angular velocity of point C (gear 3) can be found ($\phi_c = Z_c M_c$).

Frequencies of the natural or free vibrations of the system can be found by setting the denominator of Z_E equal to zero. For complicated systems, it may be well to try various values of frequencies and note

(*Continued on Page* 146)

Combining Styling with Engineered Design

By Sampson Broadwin
Ainslie Knitting Machine Co.

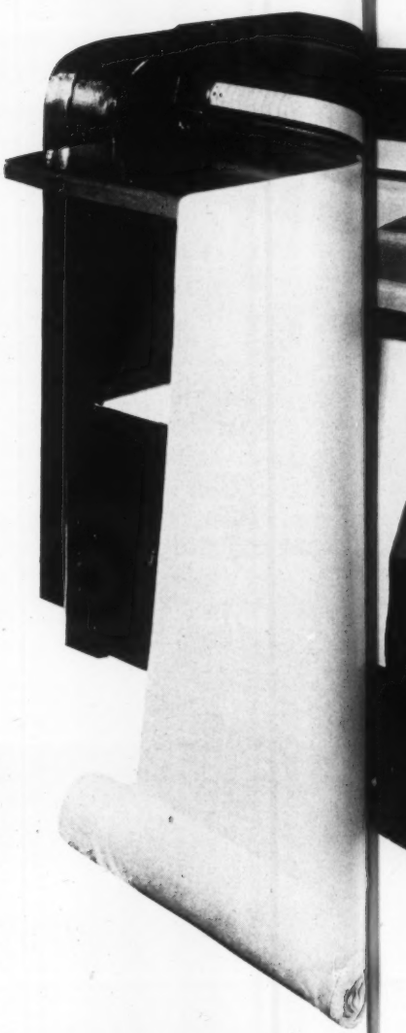


Fig. 1—Design ingenuity and standard parts effect mass production appearance in low-production machine

EVOLUTION of the design of a machine is usually a long, slow process, marked by relatively minor changes or improvements in successive models. It is unusual to find a redesigned machine such as that in Fig. 1 which, in its many refinements, differs so radically from its predecessor. The manner in which a broad knowledge and use of standard parts and materials contributed to this achievement is of vital interest to designers.

Brushing machines are a subdivision of a large class of textile machinery which puts a finish on fabrics after they come from the loom, knitting machine or other primary cloth-producing device.

Principle of the machine is evident from an inspection of the photograph and drawings, Figs. 1, 2 and 3. Cloth is fed over a polished wood table into a pair of feed rolls, thence in front of the brush roll. It is prevented from being swept around the brush by the clearer or knock-off roll. This consists of canvas vanes which move in a direction opposite to that of the brush. The fabric then falls by its own weight onto the inclined slide and thence out of the machine.

It may be interesting to note the disadvantages of the old model machine so that the improvements of the new one may be better appraised.

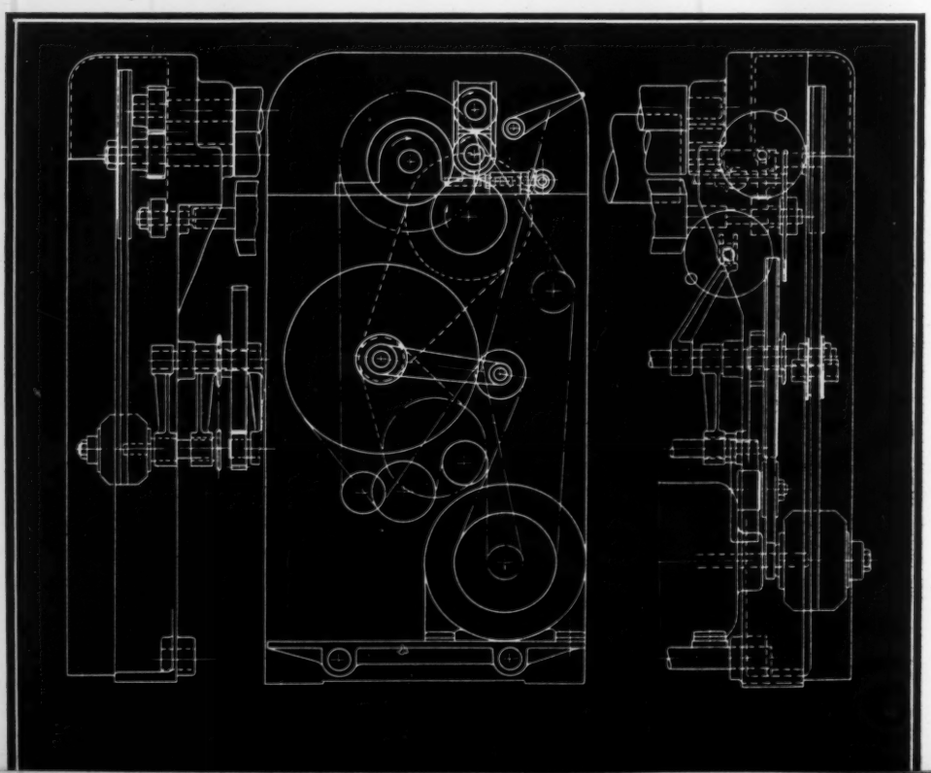


Fig. 2—Side elevation of drive system indicates manner in which drive elements are centralized and driven from a single motor

In the old model the brush roller consisted of wooden segments bolted onto several flanges which were disposed along the central shaft. After being turned in a lathe and shellacked, the wire brush—furnished in strip form—was wound spirally around this core and nailed at frequent intervals. Nevertheless, these rolls would inevitably warp. Also, in the course of time, the fabric and rubber combination forming the foundation of the wire bristle brush would stretch between the nailing points, changing the original cylindrical surface to a series of high and low spots, the high spots doing all the work and eventually failing.

No provision was made in the old machine for lint removal, and belts, chains, etc., were protected rather haphazardly by such wire gratings as could be applied after the machine was belted up to the lineshaft or motor.

In redesigning the brusher, the first step consisted in substituting a tubular steel roller for the wooden one. Since it was necessary to keep the bulk and weight down as much as possible, the diameter of the steel roll was made considerably smaller than the original wooden roll, the surface speed being maintained by faster rotation. This smaller diameter made dynamic balancing easier and, incidentally, required less brush strip.

A number of important advantages result. There is no more warpage. The brush strip is now bolted at one end and, after being wound spirally, is attached to an extension spring at the other end. At regular intervals on the periphery at this end of the steel roll are spaced threaded holes at one of which a capscrew anchors the free end of the spring. This spring acts constantly to take up any stretch of the brush strip, keeping its entire length under even tension. As the brush stretches, it is occasionally taken up by moving the capscrew to the next hole.

Another desirable feature of the new machine is the ease of obtaining exactly the amount of brushing required. In order to produce a heavier nap on the fabric (without changing the brush) three methods ordinarily could be employed: Increase the speed of the brush; reduce the speed of the feed rolls; a combination of both. This machine utilizes the last method.

Two variable-speed pulleys have been incorporated under the control of a single speed-regulating handwheel. This wheel rotates a threaded shaft carrying a nut which swivels in the speed-regulating arm. The arm is pinned to its oscillating shaft. Also fixed to this shaft on the driving side is the speed-regulating idler arm.

Affords Variable Speed

As the handwheel is rotated in a clockwise direction the idler pulley moves downward, thus permitting the V-belt to climb to a larger diameter on the variable-speed pulley which is keyed on the motor shaft. This action speeds up the brush roll pulley. A speed variation of 1:2.8 is available.

At the other end of the speed-regulating shaft is fixed a pair of arms holding a drive shaft and another variable-speed pulley. Thus, as the idler arm and pulley on the driving end swing downward, the feed roll variable-speed pulley swings down also. However, the result here is the reverse, since a downward movement decreases the driving diameter of the pulley and causes it to turn the lower feed-roll sheave at a reduced rate. This smaller pulley has a speed variation ratio of 1:2.

As a net result the clockwise rotation of the speed-regulating control wheel increases the revolutions per minute of the brush roll and simultaneously decreases the revolutions per minute of the feed rolls, producing a greater nap on the cloth. Maximum speed variation ratio is, of course, the product of both maximum pulley ratios.

A linkage joins the speed-regulating idler arm and an indicator. Various positions of the arm and thus, indirectly, the relative speeds of the brush and feed rolls are shown.

Brush-adjustment handwheel has a worm on its shaft and operates a wormwheel shaft at right angles, running lengthwise of the machine. On this shaft is fixed at each end a miter gear meshing with mates which are mounted on threaded

studs. These studs turn in nuts cast integrally with the frames of the ball-bearing pillow blocks holding the brush roller.

The right-hand pillow block is connected by an adjustable linkage with a second indicator arm moving over a second set of divisions on the common indicator plate. By operating this second wheel, both pillow blocks are moved simultaneously toward or away from the operator, thus bringing the brush closer or farther away from the lower feed roll.

Third control (of the three grouped at the right of the machine) is the starting lever. By moving this downward a series of links first disengages the brake and then rotates a three-pole double-throw switch into contact for running forward. The latch is tripped by pressing at any point on the safety bar hinged directly in front, and running the entire length, of the feed rolls.

From the central or neutral position the starting lever may be thrown upward. This movement first releases the brake and then throws the reversing switch so that the motor runs in the opposite direction. This is advantageous when it is necessary to sharpen the brush. Reversing motion is also useful when a piece of fabric becomes caught and is carried around the brush or feed roll. By jogging the starting handle in reverse, the cloth is slowly unwrapped and backed out of the feed rolls.

Two Requisites in Lubrication

When designing the lubrication system for a machine of this type, two major requisites must be kept in mind. First, there must be no possibility of lubricant getting onto portions of the machine in contact with the fabric. Secondly, the machine must be able to run for long periods without attention. With these considerations in mind, the feed-roll bearings are impregnated wood blocks. The slow rotation makes this choice suitable.

Brush roll pillow blocks, motor bearings and exhaust fan bearings are all ball-type with grease gun fittings. Idler pulleys have oilless bushings and rifle-drilled shafts with fittings conveniently placed, so that they are immediately seen on opening the doors and are thus less likely to be overlooked. Points which are more or less hidden have been "brought to the front" with copper tube extensions. A special type of fitting is used where excess grease might work out and be flung onto belts and sheaves.

As the brush processes the fabric, the loose fibers are constantly torn away and scattered about in the form of lint. This condition is taken care of by a simple dust exhaust system. A funnel-shaped hood is placed immediately below the brush and extends its full length. This terminates at the center of the machine in a rectangular opening which is converted to a circular lumen by a transition piece having a beaded edge. The inlet side of the fan also has a beaded collar attached. These two openings are joined by a short canvas tube fastened behind each bead with a leather strap and buckle, which arrangement serves a double purpose. It isolates the fan hum from the sheet metal funnel and provides a ready means of access to the fan blades.

Matter of noise reduction has been given careful consideration. Both motor and fan bases are isolated from the frame of the machine by cork pads. In addition, the fan shaft has an outboard pillow block which is neoprene isolated.

External appearance of the machine has been kept in mind from the start, and has been developed in unison with the engineering design. Hood cover and doors are of sheet metal and have large "streamlined" radii. The cover did not con-

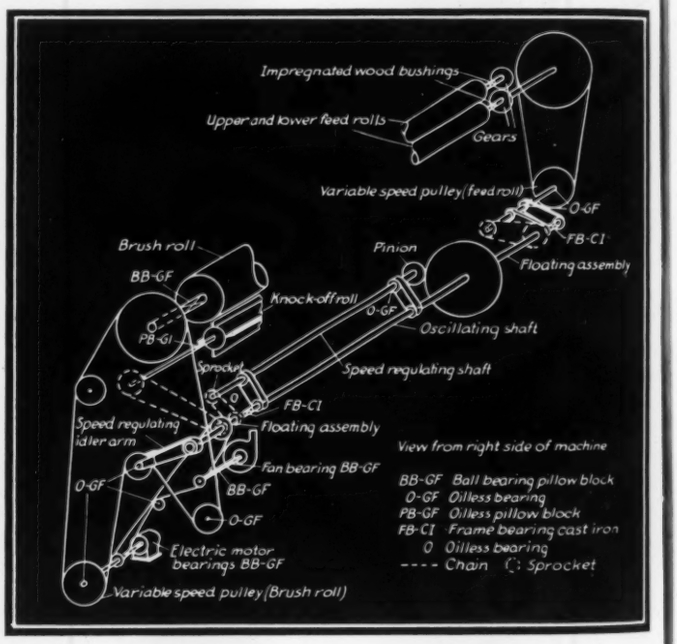


Fig. 3—Supplementing Fig. 2, projection shows the relationship between processing elements and drive

stitute a serious problem, being of single curvature, but the doors presented some difficulty. With the limited number of these machines that can be marketed, a forming die for the door was out of the question. The problem was finally solved by spinning a hemispherical shell and splitting it in four parts, each of which served as an upper corner of the door. These were then welded into the rest of the door which previously had been rolled into shape. Bottom, stiffeners and latch pad were then spot-welded in position.

Finally, a coat of high-grade glossy machine enamel is brush applied over a primer. While this coat is still wet, a spray gun filled with dry aluminum powder is directed upon it. The light silvery specks contrasting with the darker ground-coat tend to break up the otherwise monotonous appearance of the large smooth surfaces.

Designing Short Beams

By Joseph Marin*
Pennsylvania State College

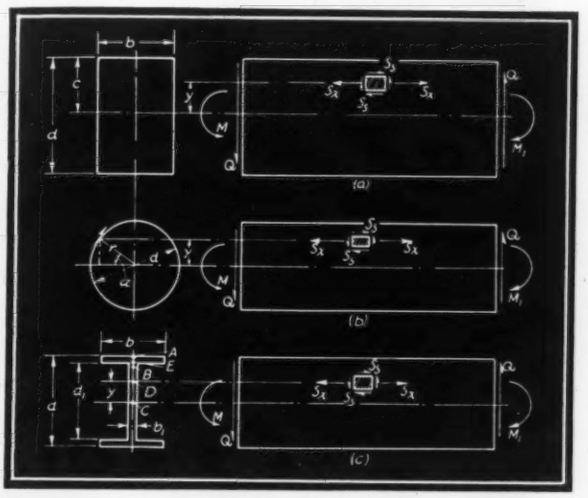


Fig. 1—Stress components at a point in beams of rectangular, circular and I-beam section

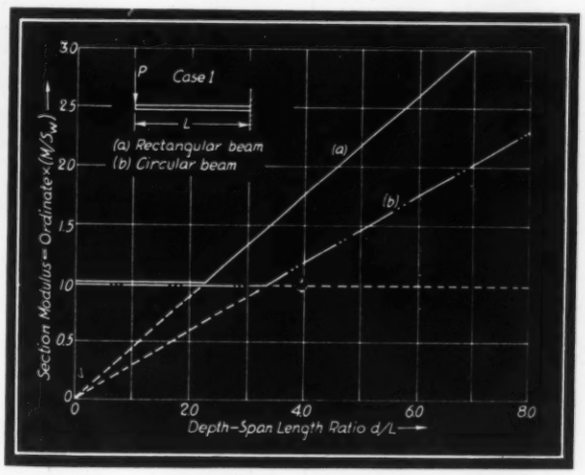
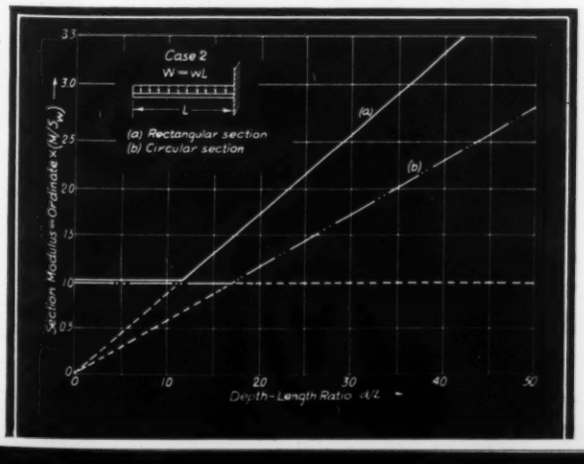


Fig. 2—Section moduli for rectangular and circular section beams fixed at one end and loaded at the other

Fig. 3—Below—Uniformly loaded rectangular and circular beams fixed at one end



FOR most beams used in structures the relative magnitudes of the cross-sectional dimensions to the span length are small. Usual design procedure provides for an allowable bending stress and deflection, and in some cases the shear stress is considered. When the beams are short, that is, when the depth is large compared to the span length, the usual procedure becomes inaccurate since the combined stress should be considered.

It is then necessary to provide for the "combined stress effect" as discussed in the previous articles of this series (M.D., Aug. and Jan.). This is done in the following examples by considering the combined stresses, using the distortion energy theory of failure for evaluating the working stresses. It is shown that the usual procedure may be considerably in error for some cases. Design charts are given for the convenience of the designer, making it possible to select the required section modulus for beams of different cross sections.

SHORT BEAMS OF RECTANGULAR CROSS SECTION: For the beam of rectangular cross section shown in *Fig.* 1a, the shear force Q and the moment M produce stress components at a point P in the beam of magnitudes

$$S_x = \frac{My}{I}$$

and

$$S_s = \frac{Q}{2I}\left(\frac{d^2}{4} - y^2\right) \quad \text{.....(a)}$$

Distortion energy for the element considered has been shown to be

$$V = k(S_x^2 - S_x S_y + S_y^2 + 3S_s^2)$$

or

$$V = k(S_x^2 + 3S_s^2) \quad \text{.....(1)}$$

since S_y is zero.

Placing the values of the stresses from Equations

*Formerly with the Illinois Institute of Technology, see Page 122.

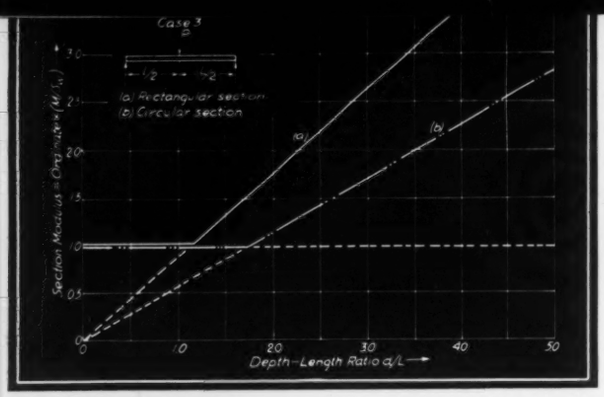


Fig. 4—Rectangular and circular beams loaded in the center and supported at each end

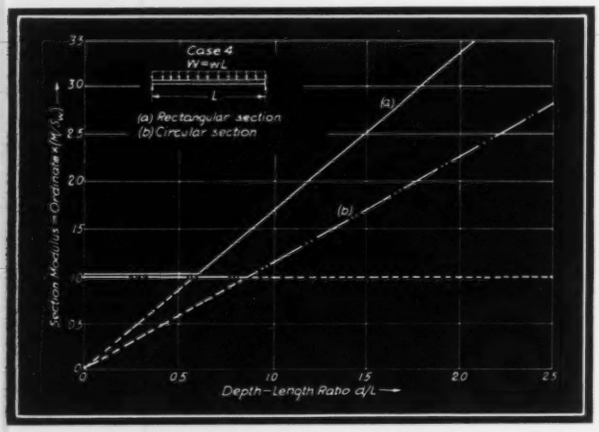


Fig. 5—Uniformly loaded rectangular and circular beams supported at each end

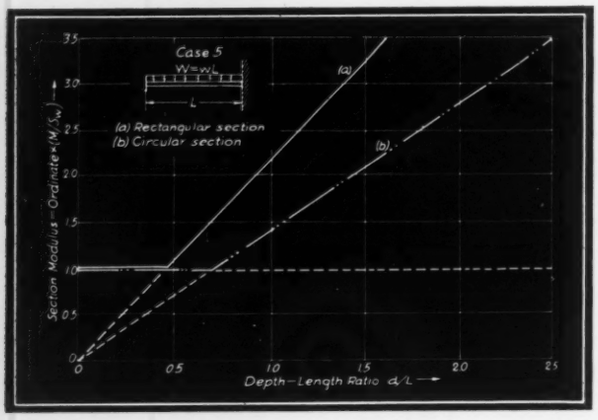
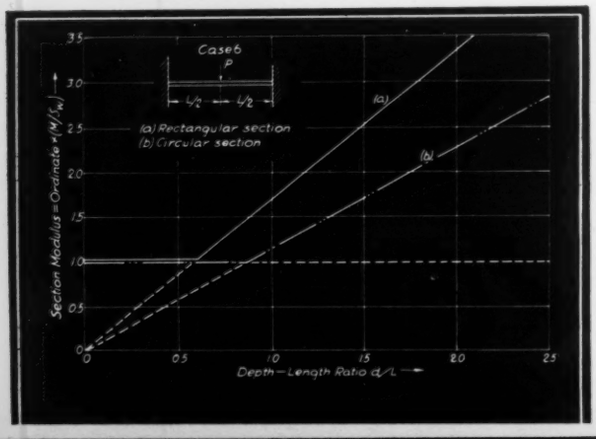


Fig. 6—Rectangular and circular beams uniformly loaded, supported at one end and fixed at the other

Fig. 7—Below—Rectangular and circular beams loaded at the center and fixed at each end



a in Equation 1, the distortion energy for the element at P is

$$V = k\left\{\left(\frac{My}{I}\right)^2 + 3\left[\frac{Q}{2I}\left(\frac{d^2}{4} - y^2\right)\right]^2\right\} \quad \text{....(b)}$$

Position of the critical element, determined by placing $dV/dy = 0$, is at

$$y = 0 \text{ or } y = \sqrt{\frac{d^2}{4} - \frac{2M^2}{3Q^2}} \quad \text{.....(c)}$$

Using these values of y the distortion energy values are, from Equation b, respectively

$$V'_{(max)} = \frac{3k}{32I} Q a^4 \quad \text{.....(d)}$$

$$V''_{(max)} = k\left(\frac{M^2 d^2}{4I^2}\right) \quad \text{.....(e)}$$

The governing value in Equations d and e depends upon the relative values of Q and M. Equating the distortion energies in these equations to their allowable value kS_w^2, the section modulus is one of the following values

$$\left(\frac{I}{c}\right) = .433\,\frac{Qd}{S_w} \quad \text{.....(f)}$$

or

$$\left(\frac{I}{c}\right) = \left(\frac{M}{S_w}\right)\sqrt{1 - \left(\frac{4}{3}\right)\left(\frac{M}{Qd}\right)^2} \quad \text{.....(g)}$$

As determined by Equation g the section modulus is always less than the value usually determined, namely, M/S_w since the quantity under the radical in this equation must always be less than one. The required section modulus is, therefore, defined by the usual value M/S_w or, from Equation f, by

$$\left(\frac{I}{c}\right) = \frac{M}{S_w}\left(.433\,\frac{Qd}{M}\right) \quad \text{.....(2)}$$

This value of the section modulus will govern for all values in the brackets of Equation 2 greater than one. To investigate this further it is necessary to select beams of particular loading and support. *Figs.* 2 to 8 illustrate some of the common cases of beams. In all of these examples the shear and moment are maximum at the same section. The values of the section moduli for each case, using Equation 2, are

CASE 1:

$$\frac{I}{c} = \frac{M}{S_w}\left(.433\,\frac{d}{L}\right) \quad \text{.....(3a)}$$

CASE 2:

$$\frac{I}{c} = \frac{M}{S_w}\left(.866\,\frac{d}{L}\right) \quad \text{.....(3b)}$$

CASE 3:

$$\frac{I}{c} = \frac{M}{S_w}\left(.866\ \frac{d}{L}\right) \quad \text{.....(3c)}$$

CASE 4:

$$\frac{I}{c} = \frac{M}{S_w}\left(1.732\ \frac{d}{L}\right) \quad \text{.....(3d)}$$

CASE 5:

$$\frac{I}{c} = \frac{M}{S_w}\left(2.165\ \frac{d}{L}\right) \quad \text{.....(3e)}$$

CASE 6:

$$\frac{I}{c} = \frac{M}{S_w}\left(1.732\ \frac{d}{L}\right) \quad \text{.....(3f)}$$

CASE 7:

$$\frac{I}{c} = \frac{M}{S_w}\left(2.592\ \frac{d}{L}\right) \quad \text{.....(3g)}$$

From Equations 3, design charts are constructed in *Figs.* 2 to 8 which show the variation in the required section modulus for different ratios of depth of beam to span length. These figures indicate that the required section modulus may be appreciably greater than that obtained by usual calculations.

SHORT BEAMS OF CIRCULAR CROSS SECTION: In some machines there are short shafts of circular cross section subjected to bending and transverse shear, as shown in *Fig.* 1*b*. Due to the transverse shear force Q, a shear stress is produced. An approximate theory for the evaluations of this stress is given by Timoshenko.† The maximum value of this shear stress occurs on the circumference and its magnitude is

$$S_s = \frac{Qr^2}{3I}\cos\alpha \quad \text{.....(h)}$$

The bending stress due to the moment M is

$$S_x = \frac{Mr}{I}\sin\alpha \quad \text{.....(i)}$$

Using Equation 1, the distortion energy for the element at Point P is

$$V = k\frac{r^2}{I^2}\left(M^2\sin^2\alpha + \frac{r^2Q^2}{3}\cos^2\alpha\right) \quad \text{.....(j)}$$

The maximum value of V is defined by placing $dV/d\alpha = 0$, or for $\sin 2\alpha = 0$. That is $\alpha = 0$ or $\alpha = \pi/2$. Using these values of the angle α in Equation j, the maximum value of V is

$$V'_{(max)} = \frac{kr^2M^2}{I^2}\left[\frac{1}{3}\left(\frac{Vr}{M}\right)^2\right] \quad \text{.....(k)}$$

Equating these two values to the allowable energy

$$V''_{(max)} = k\frac{r^2M^2}{I^2} \quad \text{.....(l)}$$

†This theory is given by S. Timoshenko in *Strength of Materials* Vol. 1, Van Nostrand Co., 1930, Page 129. The error in the magnitude of the maximum shear stress by this theory is about 5 per cent which is not high for practical purposes.

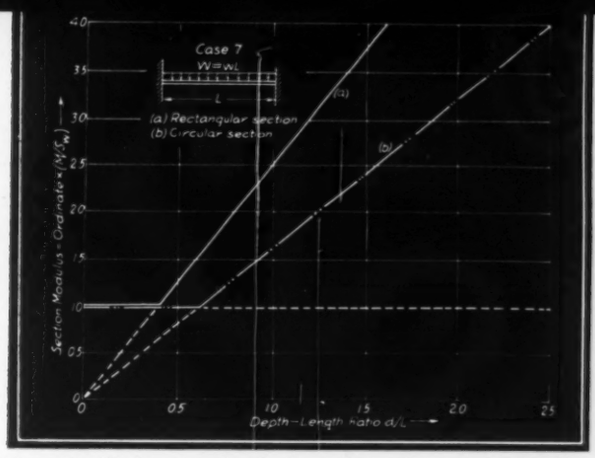


Fig. 8—Uniformly loaded rectangular and circular beams fixed at each end

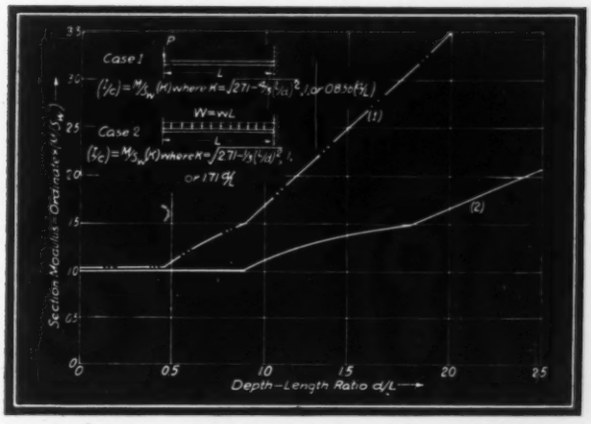


Fig. 9—Section moduli for I-beams with one fixed end loaded at one end or uniformly loaded

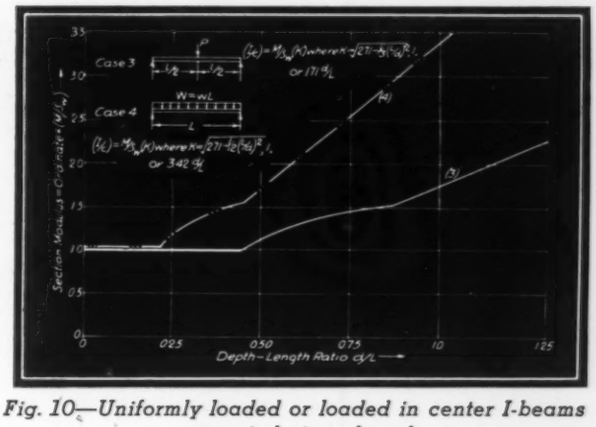
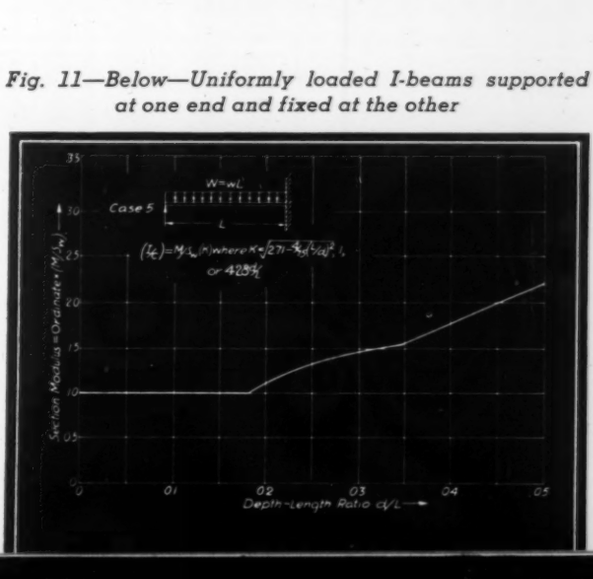


Fig. 10—Uniformly loaded or loaded in center I-beams supported at each end

Fig. 11—Below—Uniformly loaded I-beams supported at one end and fixed at the other



kS_w^2, the required section modulus is

$$\left(\frac{I}{c}\right) = \frac{M}{S_w}\left[\left(\frac{Qd}{M}\right)\frac{1}{\sqrt{12}}\right] \quad \text{.....(4a)}$$

or

$$\left(\frac{I}{c}\right) = \frac{M}{S_w} \quad \text{.....(4b)}$$

The second value of Equations 4*a* and 4*b* is that usually used and will govern unless $Qd/(M\sqrt{12})$ is greater than one in Equation 4*a*. Whether this occurs depends on the relative dimensions of the beam and loading. *Figs.* 2 to 8 show different beams commonly encountered and the required section modulus for each case becomes, by Equations 4*a* and 4*b*,

CASE 1:

$$\frac{I}{c} = \frac{M}{S_w}\left(.29\ \frac{d}{L}\right) \quad \text{.....(5a)}$$

CASE 2:

$$\frac{I}{c} = \frac{M}{S_w}\left(.58\ \frac{d}{L}\right) \quad \text{.....(5b)}$$

CASE 3:

$$\frac{I}{c} = \frac{M}{S_w}\left(.58\ \frac{d}{L}\right) \quad \text{.....(5c)}$$

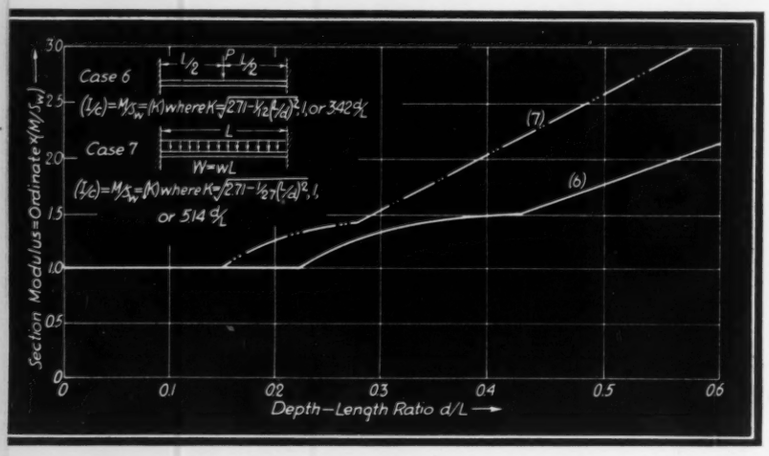


Fig. 12—I-beams fixed at each end and loaded in center or uniformly loaded

CASE 4:

$$\frac{I}{c} = \frac{M}{S_w}\left(1.15\ \frac{d}{L}\right) \quad \text{.....(5d)}$$

CASE 5:

$$\frac{I}{c} = \frac{M}{S_w}\left(1.45\ \frac{d}{L}\right) \quad \text{.....(5e)}$$

CASE 6:

$$\frac{I}{c} = \frac{M}{S_w}\left(1.15\ \frac{d}{L}\right) \quad \text{.....(5f)}$$

CASE 7:

$$\frac{I}{c} = \frac{M}{S_w}\left(1.73\ \frac{d}{L}\right) \quad \text{.....(5g)}$$

Variation in the required section modulus I/c with change in the d/L value, as determined by the above equations, is illustrated in *Figs.* 2 to 8. An examination of these curves shows that the "combined stress effect" must be considered in some cases.

SHORT I-BEAMS: Assuming the dimensions of an I-beam as shown in *Fig.* 1*c*, the bending stress for any element at a distance y from the neutral axis is

$$S_x = \frac{My}{I} \quad \text{.....(m)}$$

Using the usual theory for the shear stress for points in the web between B and C, the shear stress is

$$S'_s = \frac{Q}{b_1 I}\left[\frac{b}{2}\left(\frac{d^2}{4} - \frac{d_1^2}{4}\right) + \frac{b_1}{2}\left(\frac{d_1^2}{4} - y^2\right)\right] \quad \text{.(n)}$$

For points in the flange between A and B the shear stress is

$$S''_s = \frac{Q}{bI}\left(\frac{b}{2}\right)\left(\frac{d^2}{4} - y^2\right) \quad \text{.....(o)}$$

Using these stress values in Equation 1, the values of the distortion energies are, for points between B and C

$$V' = k\left[\frac{M^2y^2}{I^2} + \frac{3}{64}\frac{Q^2}{b_1^2I^2}(bd^2 - bd_1^2 - b_1d_1^2 - 4y^2)^2\right] \quad \text{.....(p)}$$

and for points between B and A

$$V'' = k\left[\frac{M^2y^2}{I^2} + \frac{3Q^2}{64I^2}(d^2 - 4y^2)^2\right] \quad \text{.....(q)}$$

By calculus, the maximum values of V' and V'' are, respectively

$$V_d = k\left[\frac{M^2}{4b_1^2I^2}(bd^2 - bd_1^2 + b_1d_1^2) - \frac{1}{3}\frac{M^4}{Q^2I^2}\right] \quad \text{..(r)}$$

and

$$V_c = k\left(\frac{M^2d^2}{4I^2} - \frac{M^4}{9Q^4I^2}\right) \quad \text{.....(s)}$$

Other possible maximum values of V occur at points A, B and C, and can be determined by using Equations p and q. By direct substitution of the correct y values their values are

$$V_a = k\,\frac{M^2d^2}{4I^2} \quad \text{.....(t)}$$

$$V_b = k\left[\frac{M^2d_1^2}{4I^2} + \frac{3}{64}\frac{Q^2}{b_1^2I^2}(bd^2 - bd_1^2)^2\right] \quad \text{.....(u)}$$

$$V_c = k\left(\frac{3}{64}\frac{Q^2}{I^2b_1^2}\right)\left(bd^2 - bd_1^2 + b_1d_1^2\right)^2 \quad \text{.....(v)}$$

(*Concluded on Page* 162)

Substitutes—

Replacements—

Alternatives!

By R. C. Osborn
The Hoover Co.

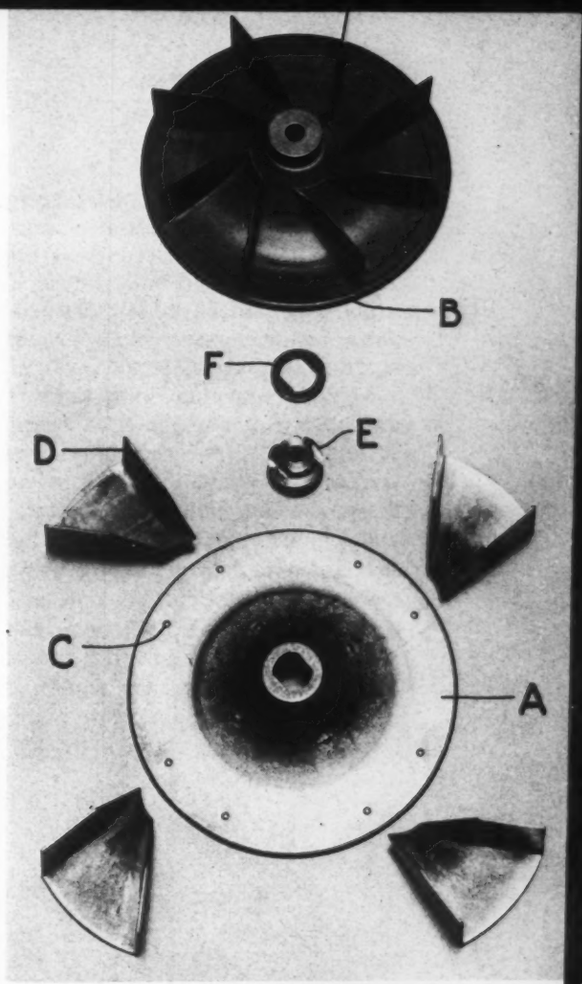


Fig. 1—By utilizing to the utmost the advantages of sheet steel stampings, an aluminum casting was replaced with little sacrifice of cost

IN THE development of any new machine the designer naturally gives careful consideration to the selection of materials for component parts. If weight is a factor in the finished machine he selects several materials of low specific gravity. His selection may then be further restricted by the processing equipment available in his plant. Electrical or mechanical requirements will probably still further limit his selection and, finally, cost will possibly be the factor which dictates the ultimate choice.

It is apparent that when substitution becomes necessary because the original material is no longer available, some sacrifice may be involved in accepting a replacement. This may be a slight increase in cost, a little additional weight, or even an effect on appearance or operation. Barring the development of some new material we may assume that in any article which has been properly designed there is little possibility of substituting materials without introducing some feature previously considered objectionable.

The development of substitutes, therefore, must be given due consideration so that the undesirable features may be kept at a minimum, both in degree and number. Obviously the problem of satisfactory material substitution is often more difficult than the preparation of the original design because of the limitations imposed by associated parts of the apparatus.

Numerous items must be considered before recommending any material as a substitute. Foremost among these is the determination of the suitability of the proposed replacement. First, the standard of quality of the product must not be lowered, which means that the substitute material must be equivalent to the original in all the requisite properties. Second, the part must be so designed that it will fit into the assembly without changing any associated elements. This is necessary not only because of the tooling problem involved, but also because the substitute may be required as a service replacement for machines already in use.

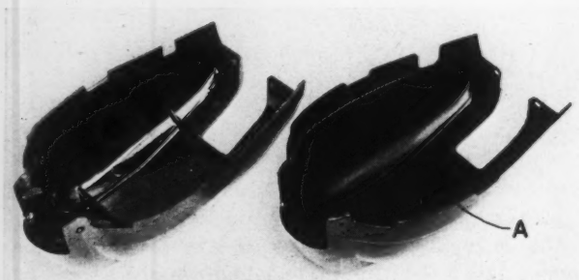
Locating a material which appears to satisfy the physical requirements does not entirely solve the problem of suitability. In the modern machine, where weight and size are held at a minimum, it is a rare instance where much excess space is available to alter the shape or size of any of the parts. Also substitute materials often are processed differently than the original. For instance, a stamped or drawn sheet metal part may be required to replace a cast or molded piece. Therefore, a real design problem is generally involved in fashioning the replacement so that it will fit into the original space and still provide adequate strength and satisfactory function.

After the material is selected and the part redesigned it is necessary to conduct tests to prove definitely that the substitute is satisfactory. Due to the fact that substitutes must often be developed hurriedly there is a temptation to forego tests when the substitution has involved only minor changes. However, the possibility of failure

in a substituted part can not be tolerated even in normal times—much less at a time when machines are so vital to the production of war materials. Therefore, it should be a "must" of every substitution program, that all redesigned machines and parts be given abuse and life tests before final approval as suitable replacements.

Next in order of importance is the probable availability of the material being considered for substitution. Here several factors must be analyzed: The location of the source of raw material, the processing equipment available to convert this material into a usable form, and the probable effect of a rapidly expanding war program on the material in question. Also, it is imperative that more than one substitute be developed for a given part in the event that the first choice becomes restricted. Further, a complete study must be undertaken to help anticipate material restrictions. Thus a sudden curtailment of delivery of certain

Fig. 2—Shortage of thermosetting plastics induced the successful substitution of a drawn steel part. The latter is shown on the right, above and below, compared with the former plastic part



materials should not find a wideawake engineering department with no substitutes developed.

An unfortunate example illustrating several of these points took place during the early period of present material restrictions. When it became apparent that aluminum, zinc and magnesium were to become strategic materials, many machines or components thereof were hurriedly redesigned for phenolic plastics. This was a natural move because intricate shapes were being cast from the above metals and, in many cases, molding was the only means by which the shapes could be retained.

Some companies, however, particularly those not experienced in plastic molding, looked upon this material as a cure-all for their material problems and hastily placed orders for molds without either investigating the availability of material or producing experimental parts for test purposes. The suddenness with which the shortage of phenolic plastics appeared shocked many manufacturers with the realization that they had large investments in molds and no material available for use in them. In addition they had no alternative substitute available and, faced with another tooling period, many were forced to suspend production.

Admittedly, it has been difficult to determine which materials would be available for the longest period. This, however, makes it even more imperative that several substitutes be developed for each material in use. Naturally it becomes costly to develop many replacements but, when it is considered that these developments may be the means of keeping a plant operating, the cost of developing several substitutes shrinks in significance.

Study of raw material sources has become increasingly important during the past several months. It has long been apparent that rubber parts should be eliminated or replaced insofar as possible because of the possibility of war in the Pacific. When the shortage of phenolic plastics first became apparent, shellac compounds appeared to be a feasible substitute for certain parts where the impact and heat resistant requirements were low. However, it was far too risky to substitute with these compounds since lac is obtained from India and transported across the Pacific.

Consider Time and Cost

Desirability of substituting for any part in such manner that no other parts are affected is primarily due to the increased tooling required if several parts are to be changed. Two factors to consider regarding tooling are time and cost. In preparing substitutes tooling time is generally more important than cost, and when two alternative materials are available and suitable for substitution the tooling time required for each may be the deciding factor in final selection.

As an example in point, if it is necessary to provide a substitute for a small phenolic plastic caster wheel, two materials are suitable and both probably available. The first is wood; the second hard rubber (made entirely from reclaimed stock). Molds for the plastic wheel are not suitable for molding hard rubber, therefore new tooling must be considered in each case. The piece cost of the two materials will be about the same, which leaves the tooling time and expense as the determining factor. It is obvious that little tooling is required to turn out a simple wood wheel, and likewise obvious that a multiple-cavity mold would require much more time and expense. Therefore, since the substitution is a temporary expedient, wood is

selected because the tooling time is short and the expense low.

Other production problems must also be considered. In these times when part of the facilities of nearly every plant is devoted to defense production, certain production departments will be overburdened while others may be handling less than their normal quota. Therefore, in the development of substitutes, production facilities must be studied so that additional work is not placed in one of the overburdened sections.

Screw Machine Overloaded

While each plant has its own particular problems in this respect, it is a general condition at present that all automatic screw machines are scheduled to full capacity. With this condition in mind it is not logical to specify any substitute which will require this type of equipment, or any equipment which is needed for more essential production. It is important that no additional equipment be demanded by the choice of an alternative material for any part because of the time element involved and the shortage of machine tools at the present time. This often places a difficult factor in the substitution formula, but the condition is as unavoidable as the shortage of raw materials and merely offers another challenge to the engineer intent upon developing replacements.

Investigation of production stocks is also a requisite of successful substituting. When it becomes apparent that an alternative material must be chosen for a given part, it becomes necessary for the engineer to determine when a substitute can be in production and make every effort to see that a sufficient stock of parts, in the original material, are on hand to extend to that date. This is generally possible if material shortages are anticipated well in advance.

Consideration of field service problems when designing has been briefly mentioned in a preceding paragraph. It is apparent that, when a substitute is provided for a given part it will sooner or later be used as a replacement in service. Will this part then require any equipment for installation or maintenance which is not available to the service man? While not foremost among the problems to consider in substitution, it is nevertheless one which must not be overlooked.

Investigate Patent Situation

No engineering department should develop a new machine without adequate investigation of existing patents. Careful patent consideration must also be obtained when redesigning any part for substitution. It may often appear unnecessary to have a patent search made when only slight changes are involved and, in the rush of developing substitutes, this may be easily neglected. However, it is sound practice to request a patent search on all redesigns for substitution and to obtain a release from the patent counselor before proceeding. Failure to do so could result in litigation.

Factory cost is likely to be the item which will suffer most in providing alternative materials. It is recognized that if, in the original design, two materials are equally satisfactory from all other standpoints the cheaper will be employed. Then, in substituting, either the discarded material must be taken, if it becomes available, or the one which is less satisfactory from a strength or functional standpoint. Since it is not logical to lower the quality standard of the machine the more expensive part must be accepted. There may be temptations, in these days of rising costs, to compromise somewhat with quality and avoid added cost when substituting. This is too dangerous to be

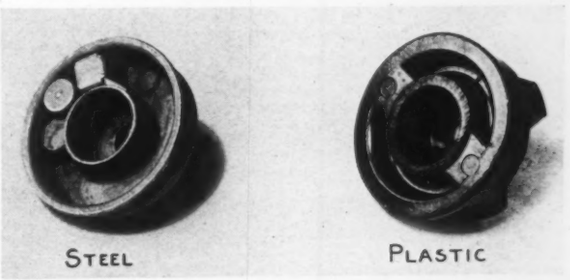


Fig. 3—Steel or plastic is used in this bearing housing and agitator end with no sacrifice of either cost or function. Parts are interchangeble

given a second thought and, if either quality or profit has to be sacrificed, let it be the latter.

All the foregoing rules governing and limiting substitution may seem elementary. It may even be said that there is danger in their simplicity, since any one of them might be neglected in consideration. The chief difficulty, of course, is the design problem generally involved. The prime requisite of satisfactory substitution is proper coordination of all the laws involved. Following them, it is often surprising what substitutions can be made and how trifling the increase in cost. In fact it sometimes happens that in redesigning for substitution a result is achieved which makes the part preferable to the original. In these cases, of course, the alternative should be retained even after the original material is again available. Adequate design consideration is nowhere more desirable than in the development of alternative materials. Out of the period of difficulty caused by material restrictions are bound to come new ideas, new designs and the development of new materials.

While each case must be given individual consideration there are certain general substitutions being made for various materials. To replace aluminum or zinc castings many excellent designs have appeared using stamped or drawn sheet steel. In many cases due to the intricate shape of the

part several steel parts are formed and joined by spot or projection welding.

Fig. 1 shows a vacuum cleaner fan before and after assembly. This was designed as a substitute for a one-piece die-cast aluminum fan. It is shown here not only as an example of steel for aluminum replacement, but also because many of the laws of substitution, previously discussed, were involved in its development.

The requirements for this part were as follows: The blades must withstand the impact of small pebbles and the abrasion of sand and grit striking them at high speed; the weight must be held at minimum, both because of the effect on the overall weight of the cleaner and the vibration effect of residual unbalance; it must have exactly the same shape and dimensions as its aluminum counterpart so that it might be used as a replacement both in production and service, and also it must provide

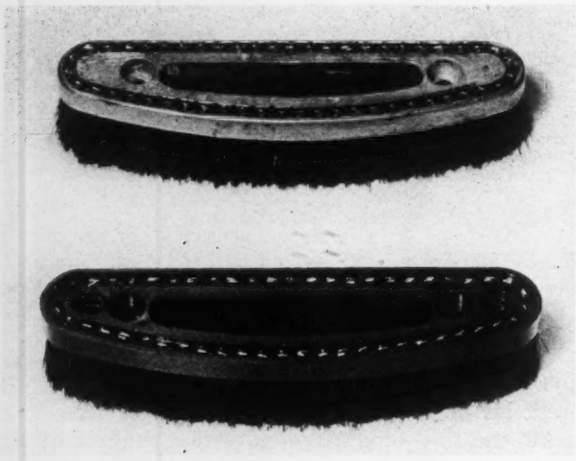


Fig. 4—For low-stressed parts not subject to heat, direct substitution may often be achieved by thermoplastics, replacing an aluminum casting

the same airflow. Naturally it was desirable that the tooling and piece costs be kept as low as practicable.

The shroud *A*, which curves upwardly toward the center, is cupped from light-gage sheet steel and flanged on the periphery, at *B*, both to provide stiffness and to maintain a dimension equivalent to the thickness of the aluminum fan. Dimples *C* are pressed in the shroud so that the blades may be attached by projection welding. Blades *D* are formed in pairs from fairly hard sheet steel, and all four sets are projection welded to the shroud in one operation. The flatted steel hub *E* fits through the similarly shaped opening in the shroud, washer *F* is placed on the hub and the hub then staked on the underside. Both faces of the hub are finished and the hole reamed after assembly. Balancing is accomplished by applying solder to the underside of the shroud.

It is interesting to note that in this rather straightforward substitution there were existing patents which had to be considered in fabricating a steel fan, and the co-operation of the patent counselor was required to provide a satisfactory design. Further, it was necessary to conduct several tests to determine the proper material for the blades, so that they might provide maximum impact resistance for a minimum weight. Tests on the final models indicate that the substitute is equivalent to the original in strength and life. The only penalties in this substitution are trifling increases in weight and cost.

Providing replacements for phenolic plastic parts is generally more difficult than for cast metals. Because of their insulating properties phenolics are often used in electrical parts, and substitution generally is difficult because of the insulating problem involved. However, a combination of sheet steel and fiber can often be conceived as a plastic substitute. In some cases where the temperature requirements are low and dimensional stability is not required, injection molded cellulose acetate may be a satisfactory substitute, as indicated in *Fig.* 4. However, the limitations of this material must be understood and care used in recommending it as a replacement.

Steel Replaces Plastic

Where no electrical problems are involved sheet steel can often be used as an alternative for plastic. *Fig.* 2 shows a steel vacuum cleaner motor hood and the phenolic plastic part it replaces. The edges of the steel hood are turned in at *A* to eliminate sharp edges and to approximate the thickness of the plastic hood at the points where it fits on the cleaner.

It happens occasionally that there are two materials available for a given part on which the piece costs are almost identical. An example is indicated by agitator ends and bearing housings, *Fig.* 3, produced from steel and plastic. Both are equally satisfactory and both have been used, on different models, depending upon which is best adapted to a particular agitator design. When it becomes necessary to replace the plastic with steel because of availability, a material is used which in this case is really an alternative, not a substitute. Because of the psychological effect of the word substitute, there are those who prefer to refer to all replacements as alternative materials.

Call them alternative materials, replacements, or substitutes as you choose, but develop them for all machines or parts which are vital to your company or to the Nation's war effort. This is essential; no one can prophesy what changes in materials may be required in the next few years. Study the trends in material availability, check your own production facilities, redesign carefully and, above all, test well before replacement. Substitute—but safely.

Isolating Vibration through Use of Rubber

By Walter C. Keys
United States Rubber Co.

BECAUSE rubber is a poor conductor of noise and because it can be fabricated into economical, simple and effective springs, or mountings, it is now widely used as one of the materials essential in many types of modern mechanism. This is evident in aircraft, machine tools, locomotives and other types of machines directly or indirectly involved in the defense program.

Purpose of this paper is to deal with rectilinear vibration and (*a*) to illustrate a few practical applications of rubber, (*b*) to present typical quantitative results, (*c*) to include data as to resonance frequencies of vibratory movement of mountings made of typical rubber compounds bearing typical safe loads, and subjected to a range of vibrations such as are encountered in many actual applications.

Theory of vibratory behavior is well explained in several excellent books on the subject. In "Mechanical Vibrations" by Lieut. Commander J. P. Den Hartog, U.S.N.R., appears

CONSTITUTING a logical sequel to the article, "Simplifying Design of Rubber Mountings," in the January issue, this article details design considerations in applying such mountings to machines. Abstracted from a paper presented at the A.S.M.E. annual meeting, practical means of determining and isolating vibration are discussed

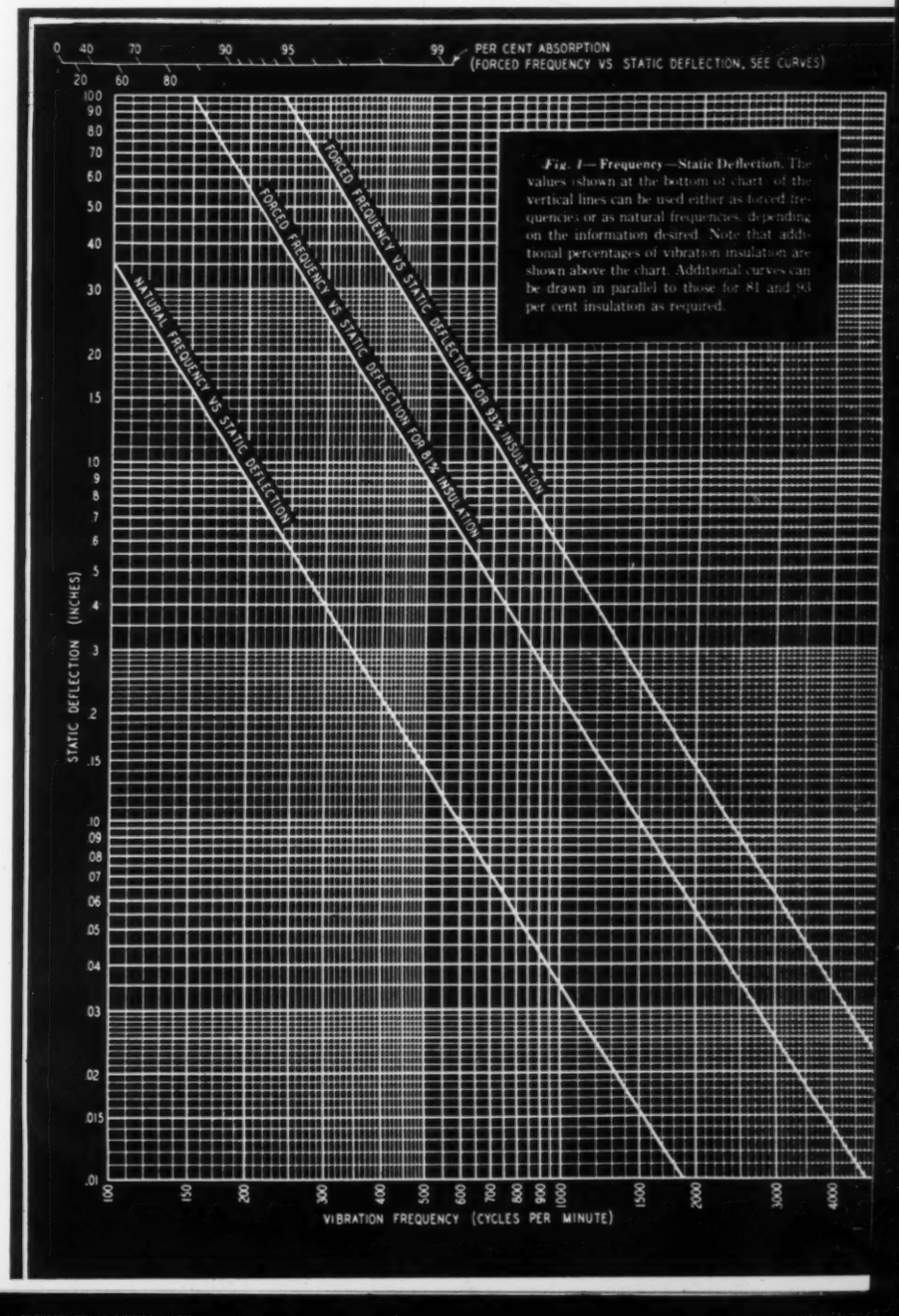


Fig. 1—By drawing lines parallel to those on the graph and intersecting the scale at the top of the chart any desired percentage of isolation may be obtained

Fig. 1—**Frequency—Static Deflection.** The values shown at the bottom of chart of the vertical lines can be used either as forced frequencies or as natural frequencies, depending on the information desired. Note that additional percentages of vibration insulation are shown above the chart. Additional curves can be drawn in parallel to those for 81 and 93 per cent insulation as required.

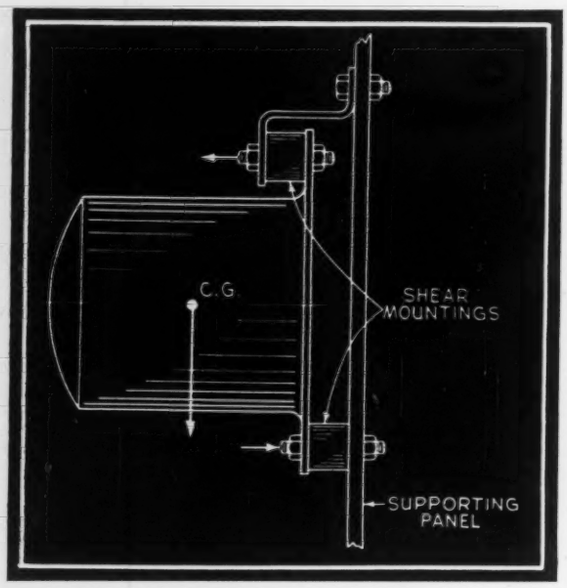


Fig. 2—Difficulty of applying compression to vertical mountings which absorb vibration in shear is overcome by this arrangement

the following referring to the effectiveness of springs (or mountings) used to reduce transference of vibration:

$$Transmissibility = \frac{spring\ force}{impressed\ force} = \frac{transmitted\ force}{impressed\ force}$$

Where damping is negligible it is further expressed as

$$\frac{1}{1-\left(\frac{forced\ frequency}{natural\ frequency}\right)^2}$$

For convenience, in this paper the quantity

$$\frac{forced\ frequency}{natural\ frequency}$$

is designated as the "frequency ratio".

Relationship between natural frequency and static deflection of a supporting spring which deflects according to Hooke's law, is

$$Natural\ frequency\ (per\ minute) = \frac{188}{\sqrt{static\ deflection\ (inches)}}$$

The foregoing apply to an undamped, single-degree system and are substantially correct for rubber springs.

Chart Aids In Selection

Chart shown in *Fig.* 1 gives, in terms of deflections, the natural and forced frequencies for transmissibilities of 81 per cent (frequency ratio 2½:1) and 93 per cent (frequency ratio 4:1). Curves for other transmissibilities can be drawn in, using the guides at top of the chart. This chart is useful in establishing the static deflection of mountings required to absorb a wide range of forced frequencies.

Transmissibility, as defined theoretically, provides the ideal solution to rectilinear vibration problems. However, in actual cases it is seldom possible to change only the stiffness of mountings, hence the actual reduction of vibratory amplitude may be either slightly greater or less than the calculated transmissibility. This is evident in the actual results given herein.

For convenience, the term "amplitude residue" is herein used to designate

$$\frac{amplitude\ of\ movement\ resiliently\ mounted}{amplitude\ of\ movement\ rigidly\ mounted}$$

referring to the vibratory movement of that portion of any mechanism or structure to be protected by the mountings. This "amplitude residue" is equal to the transmissibility under ideal testing conditions which, unfortunately, are rarely encountered. Hence transmissibility is used as our goal and "amplitude residue" as a measure of accomplishment.

In general the engineer requires the following information in attacking problems involving iso-

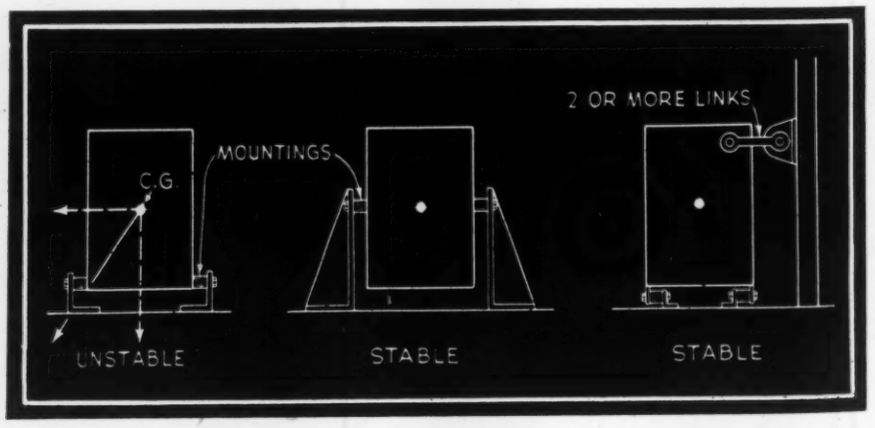


Fig. 3—Where appreciable horizontal forces are experienced, either of the two right-hand supporting methods is applicable

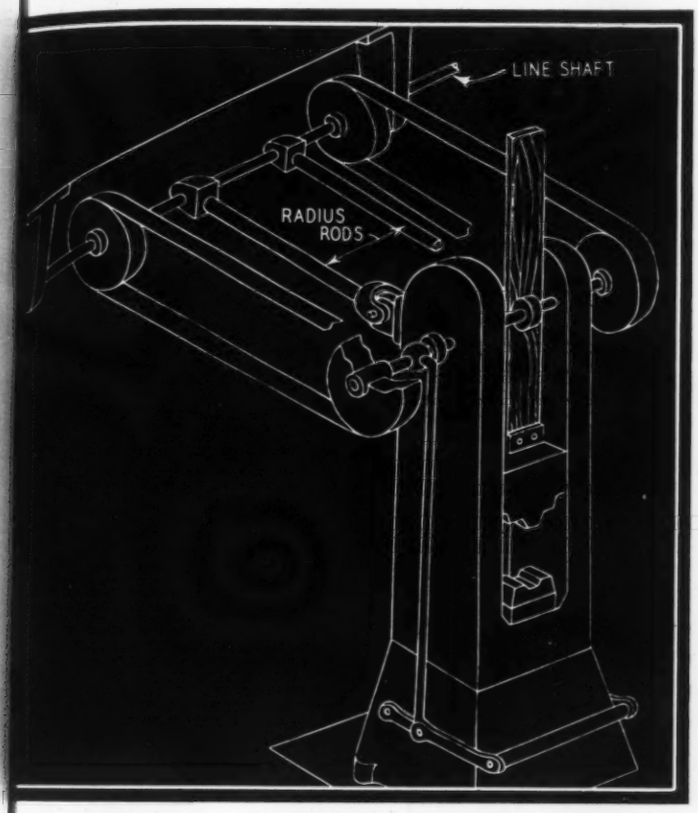


Fig. 4—Objectionable unsteadiness is overcome by use of radius rods in board drop hammer application

lation of vibration by means of resilient supports:

1. Total weight to be supported
2. Location of center of gravity
3. Lowest frequency of vibration to be insulated
4. Direction and plane of the vibration
5. Reactions (if any) to be resisted by the mountings (such as torque, forces due to driving belts, chains, gears, etc.)
6. Number, location and size of attaching bolts
7. Type, location and size of all connections from resiliently supported unit to foundation members (such as conduits, piping, driving shafts, etc.)
8. "Rate per inch" or spring constant of such connections
9. Type of supporting foundation
10. Clearances between parts of supported unit and adjacent members not supported by the mountings
11. Proximity of oil, water, temperature, exposure to sunlight or ozone
12. As complete information as possible regarding the conditions of use.

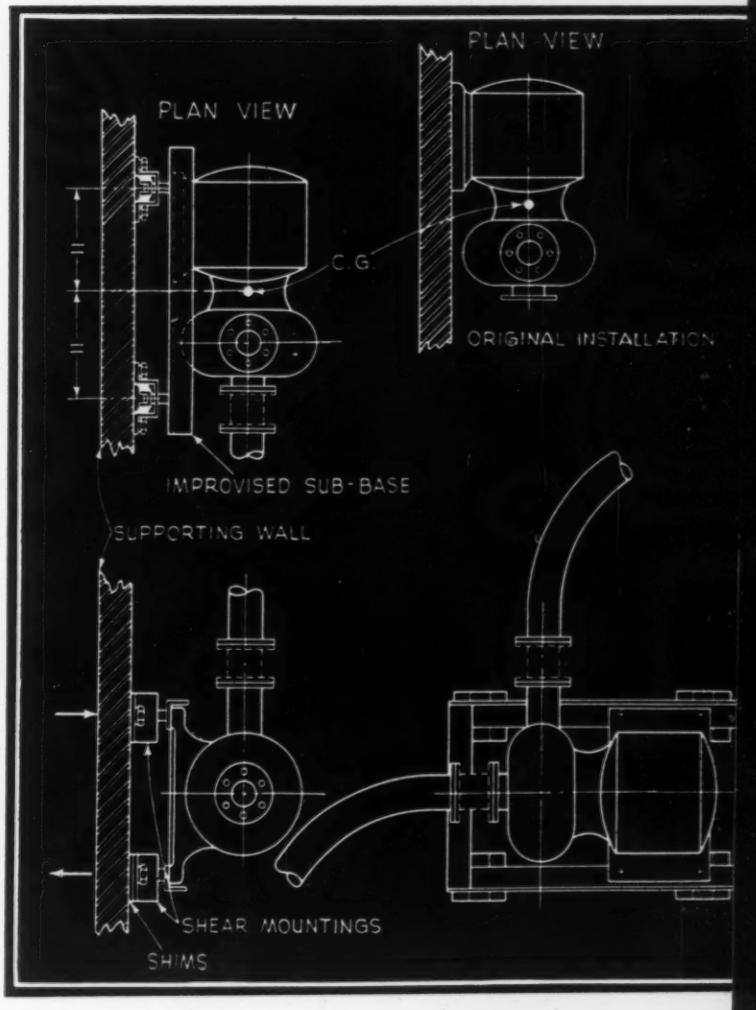
In general a wall of rubber is more flexible in shear than in compression. It is therefore customary to install the shear planes of mountings parallel to the plane of vibratory movement of the supported unit unless prevented by special conditions such as the necessity of withstanding heavy belt tension.

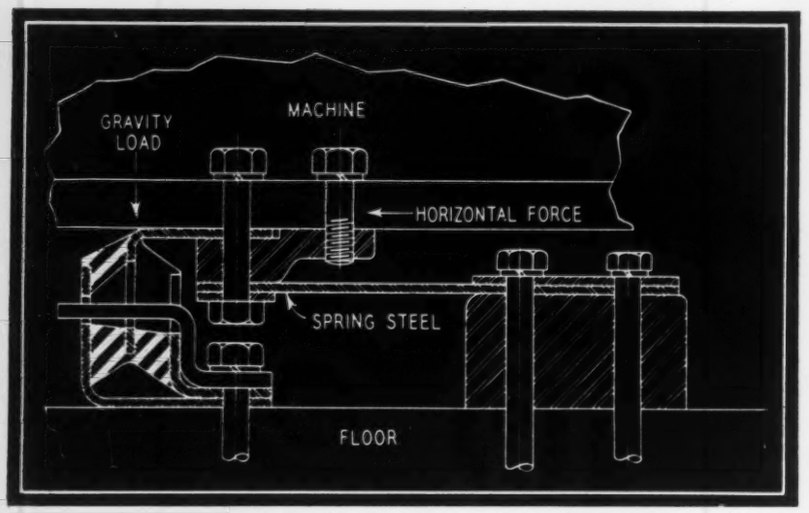
The average, simple problem is readily solved by mountings which provide the deflection indicated on the chart, *Fig.* 1. In almost all industrial work a frequency ratio of 2½:1 produces satisfactory results. (Frequency ratio is forced frequency divided by natural frequency.) In exceptional cases where the supporting floor is very flexible it is necessary to use a frequency ratio as high as 8:1, but this is not likely to be exceeded.

Horizontal Vibrations Absorbed in Shear

Where the vibration is in a horizontal plane it can usually be absorbed most economically by installing the machine on rubber-to-metal sandwiches carrying the gravity load in compression and absorbing the vibratory movement by deflecting in shear. The required horizontal stiffness can be determined by assuming gravity to act horizontally and obtaining from the chart the required static deflection. The total load (pounds) divided by this static deflection (inches) gives the horizontal "rate per inch" or spring constant of all of the

Fig. 5—Where mountings may be unequally loaded a sub-base will permit identical mountings, equally loaded, at all support points





supporting mountings. Mountings must be designed (or selected) so as to have adequate carrying capacity in compression while at the same time having the proper stiffness in shear. Furthermore the stiffness in compression must be such as to avoid resonance vertically with the horizontal vibration. Note that the actual dynamic horizontal deflections of the mountings may be, and usually are, much less than the assumed static horizontal deflection obtained from the chart.

Since the natural frequency of the supported mechanism is less than the forced frequency, the mechanism may pass through resonance when changing to or from its operating speed. This will produce a relatively large deflection which usually subsides quickly. In extreme cases such large deflections are limited in extent by rubber bumpers which, however, must not be in contact when machine is normally operating. Static bond stress is usually kept at 25 to 50 pounds per square inch. The stress on the rubber-to-metal bond is easily determined when the shear deflection is known:

$$\textit{Bond stress (psi)} = \frac{\textit{shear deflection}}{\textit{rubber thickness}} \times \textit{shear modulus}$$

It is generally considered good practice to stress

Fig. 6—Top—Arrangement prevents horizontal motion but absorbs vibration in vertical plane

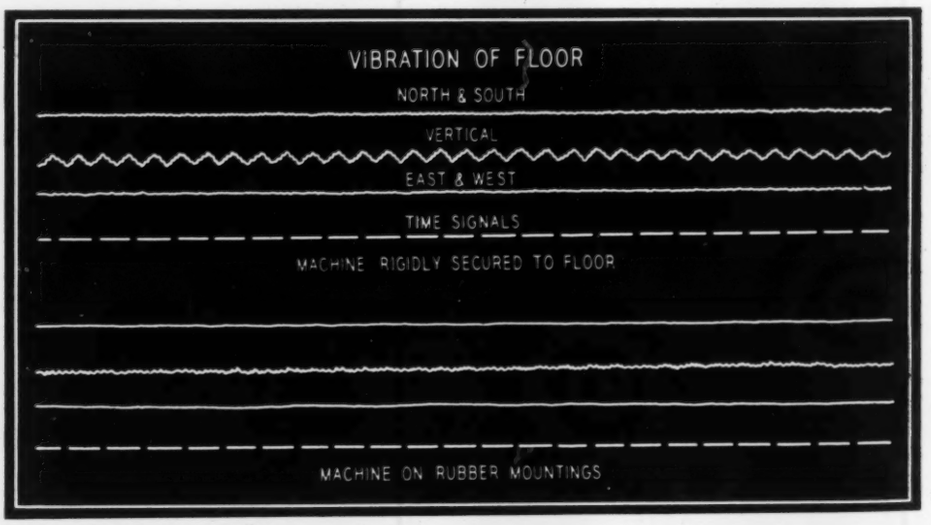


Fig. 7—Right—"Before and after" vibration records of a supporting floor, taken during operation of machine

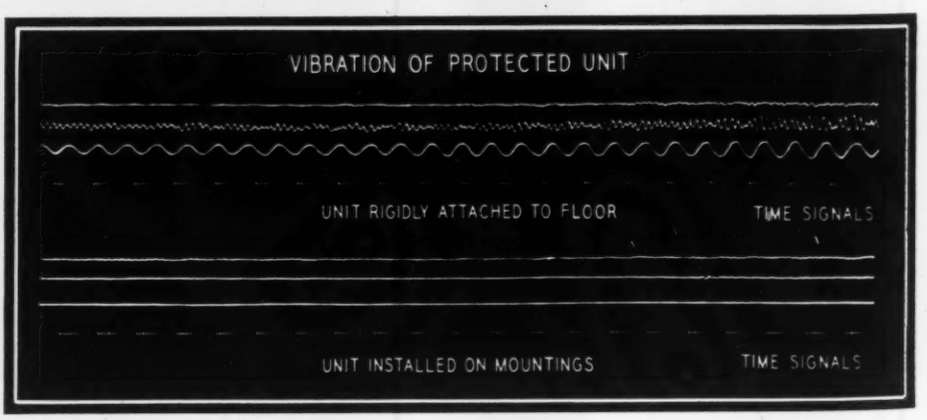


Fig. 8—Right—Upper chart is a record of machine-transmitted vibrations which disturbed laboratory apparatus. Rubber mountings effected result shown below

under compression all rubber elements which are to be stressed in shear. An unusual installation is that of *Fig.* 2 in which the arrangement of shear mountings produces compressive stress on the rubber which absorbs the vibration by deflecting in shear.

Illustrated in *Fig.* 3 are the disposition of mountings and the use of links to assure stability in cases where the resiliently supported unit is subjected to appreciable horizontal forces in addition to gravity. *Fig.* 4 illustrates a method of steadying a board drop hammer driven from a lineshaft. The radius rods overcome an objectionable teetering of the machine.

Determining Center of Gravity

Frequently the engineer is required to prescribe mountings for a machine assembly the location of whose center of gravity is unknown and cannot be obtained from the manufacturer. In such cases the machine can sometimes be placed on skids resting on a pipe. The machine can be rolled on the pipe until it balances. The center of gravity will be above the line of contact of the pipe with the skid; a second trial with the pipe at 90 degrees to its first position will establish a second line above which the center of gravity is also known to be. If necessary to know the height of the center of gravity, tip the machine until it balances over an edge of the base and the center of gravity will then be vertically above that edge.

In cases where mountings are unequally loaded the stiffness of each mounting should be chosen so as to deflect the required amount under the load imposed upon it. In cases such as that of *Fig.* 5 a sub-base may be secured to the mechanism in such manner as to permit the use of identical mountings, equally loaded, at all supporting locations.

Shown in *Fig.* 6 is an arrangement in which vertical insulation was required but horizontal movement could not be tolerated; this was prevented by a single-plate steel spring connecting the supporting floor with the supported machine.

Connections Affect Mounting

Stiffness of all connections from supported unit to foundation members must be taken into account when mountings are prescribed. A mechanism may be installed on mountings which entirely support it, and thereafter it may be connected to some more or less flexible conduit, pipe, etc., which is also joined to foundation members. The apparent static deflections must be obtained by adding together the rates per inch (or spring constants) of all mountings and connections, and dividing this sum by the total load to be carried. From this apparent static deflection the natural frequency and frequency ratio can be determined. Failure to follow this procedure may result in resonance and complete dissatisfaction.

Sometimes the frequency of disturbance can be easily established without instruments, as follows:

1. Secure a sharp pencil to the vibrating machine
2. Move a sheet of paper (contacting the pencil point) for 6 seconds, approximately at right angles to the direction of movement of the pencil which will draw a wavy line on the paper. Ten times the number of wave tops is the frequency per minute. The approximate amplitude of vibratory movement can also be determined in this manner.

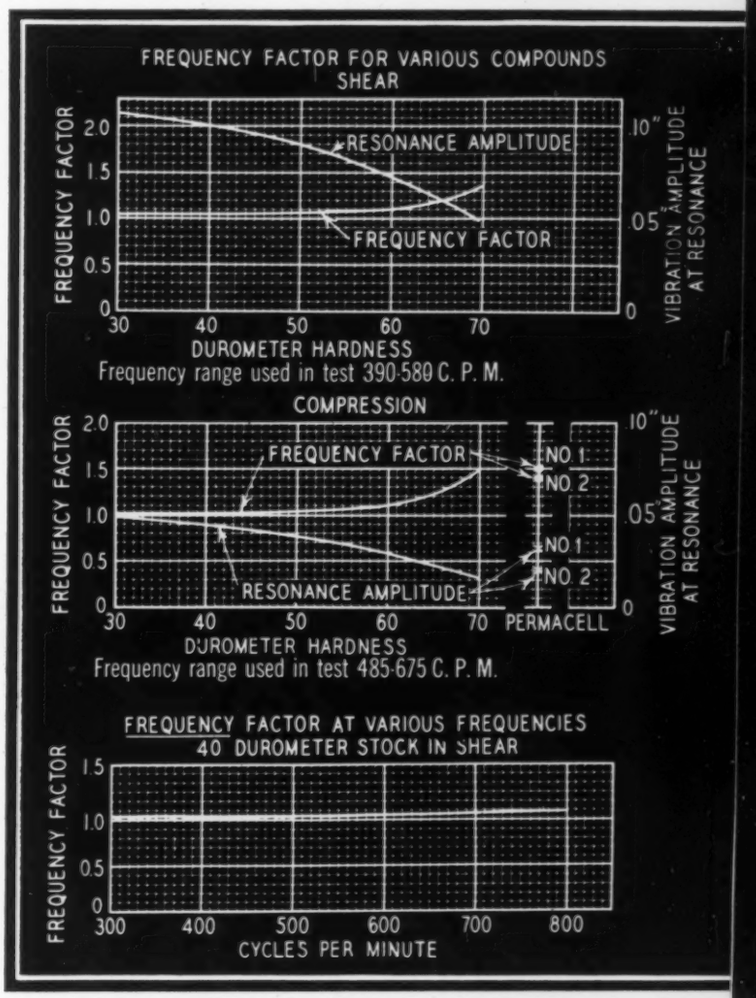


Fig. 9—Charts permit the determination of factor by which calculated resonance frequency must be multiplied to determine actual resonance frequency

The strobotac or some modification thereof may be of great value in studying the behavior of machinery. Moreover it is frequently possible to operate one part only of a complicated mechanism to study the effect of that part on the behavior of the whole.

Mountings should be kept free of oil and should

(*Continued on Page* 150)

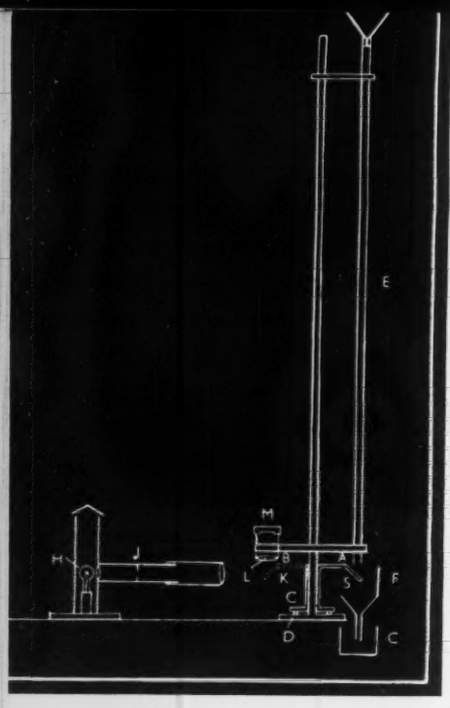


Fig. 1—Investigation of superficial hardness is accomplished in this apparatus by measuring the change in surface reflectivity caused by the impact of grains of sand

Grains of Sand Determine Hardness

By Bruce Chalmers*

ATTEMPTS to measure the hardness of thin layers, particularly of brittle materials, have met with little success. This is due largely to the fact that a very small indentation is difficult to produce under standard conditions and is difficult to measure accurately. Also, the properties of the underlying material may exert a profound influence on the result.

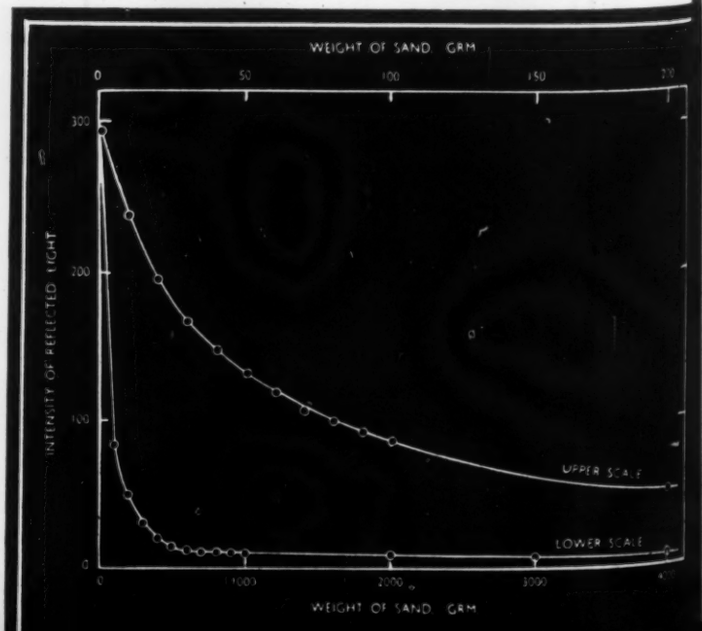
Existing methods of measuring the hardness of metals in thin layers depend on (a) the scratch test[1]; (b) the micro-indenter[2], in which a very light load is applied to a pyramid indenter, and (c) the micro-indentation test[3] in which the indenter is fashioned to give a rhomboid shape.

A new method of measuring hardness, developed primarily for thin electroplated coatings, disclosed that the results relate to the properties of an extremely thin layer of the metal and are sensitive to the treatment to which the surface has been subjected. The method is based on the principle that while it is difficult to apply a small indenting force under accurately standardized conditions, it is possible to apply a large number of such forces in such a way that, while each is not under control, the result is statistically definite.

The procedure is to drop a large number of grains of sand, or particles of emery, from a fixed height onto the specimen. Particles are of varying shapes and, within limits fixed by the screening of the sand, of varying size. They are, in addition, randomly orientated when they hit the surface. The impressions in the surface therefore vary widely in shape and size, but if a sufficiently large number of particles is used, the average shape and size of the pits depend only on the hardness of the material, while the number of indentations depends on the amount of sand used. It is therefore necessary to measure the average size of the indentations, and this is carried out by measuring the reduction in the reflectivity of the surface.

The instrument consists essentially of two parts: A device for dropping known quantities of sand onto the surface under examination from a known height, and means of measuring the specular reflectivity of the surface. The instrument, in its simplest form, is illustrated in *Fig.* 1, in which the specimen *S* can be moved to either of the two

Fig. 2—Variation in reflectivity with the total quantity of sand is essentially hyperbolic in function



*Physicist, Tin Research Institute. Abstracted from *The Journal of the Institute of Metals,* London, 1941, Vol. 67.

[1]H. O'Neill—*The Hardness of Metals and Its Measurement,* London, 1934, Page 137.

[2]H. Hanemann and E. Bernhardt—*Z. Metallkunde,* 1940, Vol. 32, Page 35.

[3]C. G. Peters and F. Knoop, *Metals and Alloys,* 1940, Vol. 12, Page 292.

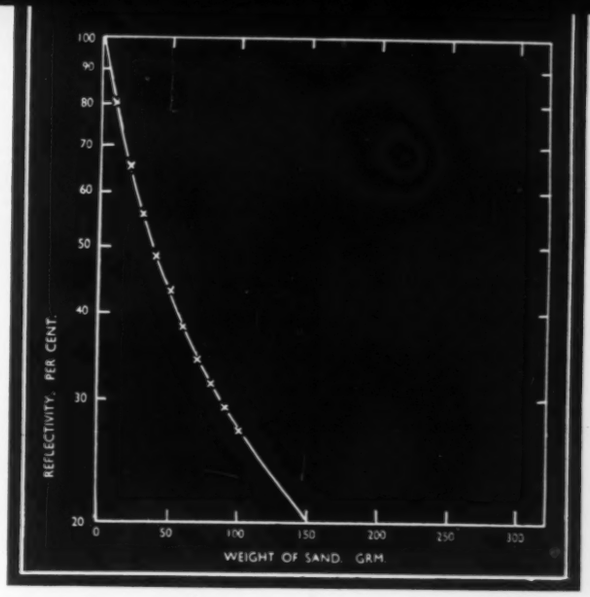


Fig. 3—Right—Logarithmic plot of reflectivity ratio against total weight of sand is practically linear

positions *A* and *B*, in each of which it is definitely located by three balls on the sole-plate *C*, this engaging in three of six holes in the baseplate *D*.

In the position *A* the specimen is under the end of the tube *E*, of length about 1 meter, to the top of which is attached a funnel. The required quantity of sand is placed in the funnel and, after striking the specimen, the sand is deflected by the baffle *F* into the container *G*. The *B* position is that in which the measurement of reflectivity is made. A six-volt headlamp bulb *H*, enclosed in a suitable housing, projects a converging beam of light in such a way that the image of the aperture *J* is focused on the specimen at *K*, at the center of the ellipse that is affected by the sand. The specularly reflected light is collimated by the lens *L* onto the photocell *M*, the output of which is measured by means of a galvanometer.

Compensates for Voltage Change

An alternative to this method of measurement is to balance the output of the photocell *M* by means of a second photocell, operating from the same lamp *H*. Intensity of the light reaching the latter cell is controlled by a pair of "polaroid" screens, one of which is fixed while the other can be rotated. The position of the rotatable polaroid is observed from a pointer attached to the rotating tube. The second photocell is connected to the same galvanometer as *M* so that the two photocells tend to cause deflections in opposite directions. In measuring reflectivity, the polaroid is rotated until there is no deflection of the galvanometer. Intensity of light reaching each of the photocells is then read off from the position of the pointer attached to the polaroid. The advantage of the null method of observation is that changes of light intensity brought about by variations in line voltage do not affect the accuracy of the readings.

Procedure adopted in carrying out a measurement is first to clean the surface of the specimen and to clamp it in the specimen holder. The reflectivity is measured; the specimen is then rotated to the *A* position, and a chosen amount of sand is placed in the funnel. When all the sand has passed through the tube, the specimen is turned to the *B* position, air is blown against it to remove fragments of sand that may be adhering to it, and the reflectivity is again measured. This is repeated until the reflectivity has dropped below one-half of its original value.

Variation of reflectivity with the quantity of sand used is illustrated in *Fig.* 2. Experiments show that the graph obtained is independent of the unit quantity of sand chosen. The appearance of different surfaces after the same amount of sand action is shown in *Figs.* 4, 5 and 6.

It is therefore possible in practice to express the hardness in terms of the decrease in reflectivity, without reference to the final value. The curve, *Fig.* 3, obtained on the logarithmic scale is nearly linear, in which the ratio $Z=R_m/R_o$ is plotted against sand weight. R_m is reflectivity after the action of *M* grains of sand; R_o, that of the original surface. The surface hardness is expressed as the weight of sand, in grams, required to reduce *Z* to .5.

Testing procedure, although differing in many respects from the conventional methods, must be regarded as a type of hardness test because it measures the resistance of the material to deformation. More specifically, the indentations are made by impact and not by static loading and the material on which the test is made is a thin layer near the surface; the hardness of the material nearest the surface has the greatest influence on the result of the test. Consequently the existence of a superficial layer with properties differing from the underlying material can be demonstrated.

Fig. 4—Cast speculum metal after the action of 50 grams of sand

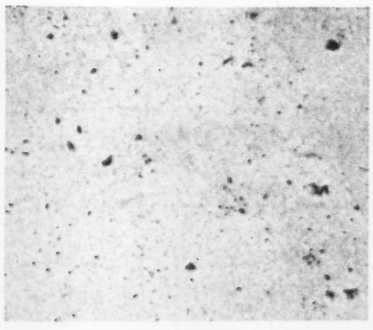
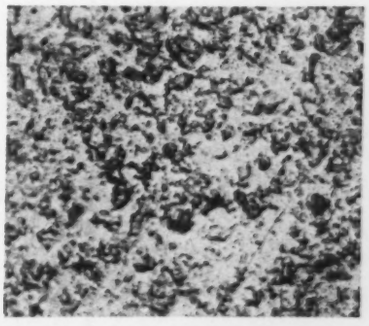


Fig. 5—Brass surface after the action of 50 grams of sand, X500

Fig. 6—Tinplate surface after the action of 50 grams of sand, X500



United

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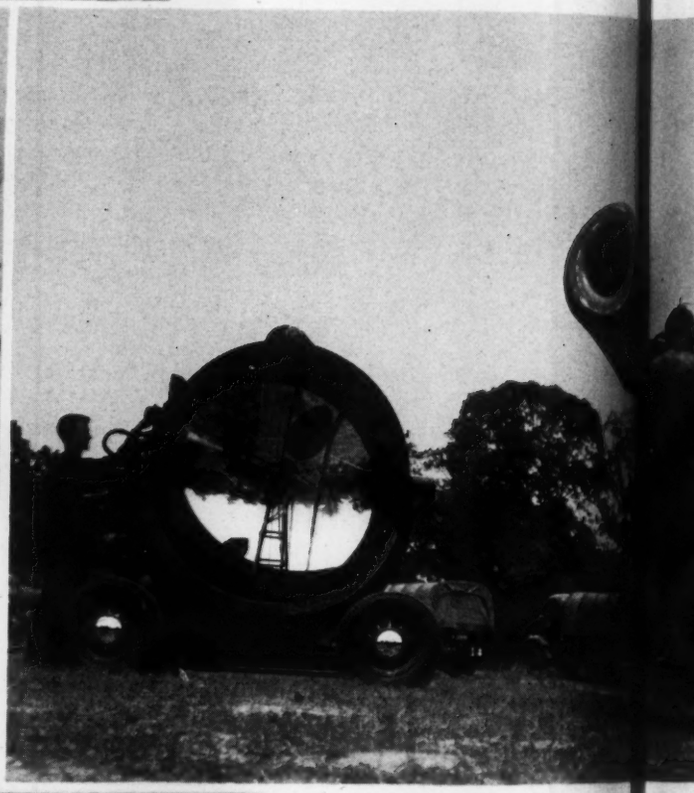


Top—In Martin B-26 bomber two Pratt & Whitney 18-cylinder engines, each rated at 1850 horsepower, drive two four-bladed, full-feathering propellers

Above—Armed with three machine guns and a Thompson sub-machine gun, Army's Half-Trac, M-2, is used as a combat vehicle and to tow artillery field pieces

Above—Searchlight and sound ction
antiaircraft night defense bat "Ears"
to "facilitate ing of

Left—Mount for 155-millimeter gun is
Unit is detached from diesel tr before

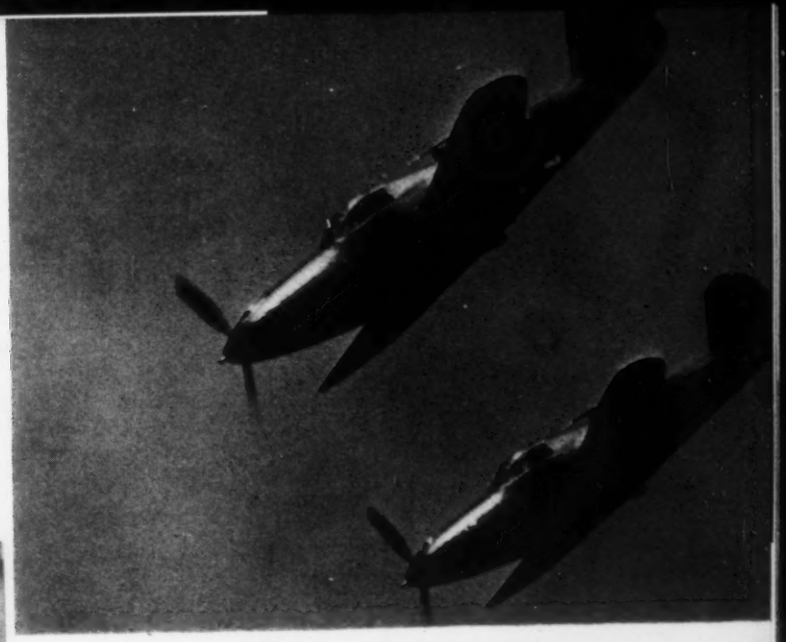
Below—Speed and maneuverab f moto
messenger service and fas ement

Right—Heavy tanks mounting imeter
are the largest and heavi the Ar

tes
ar Machines

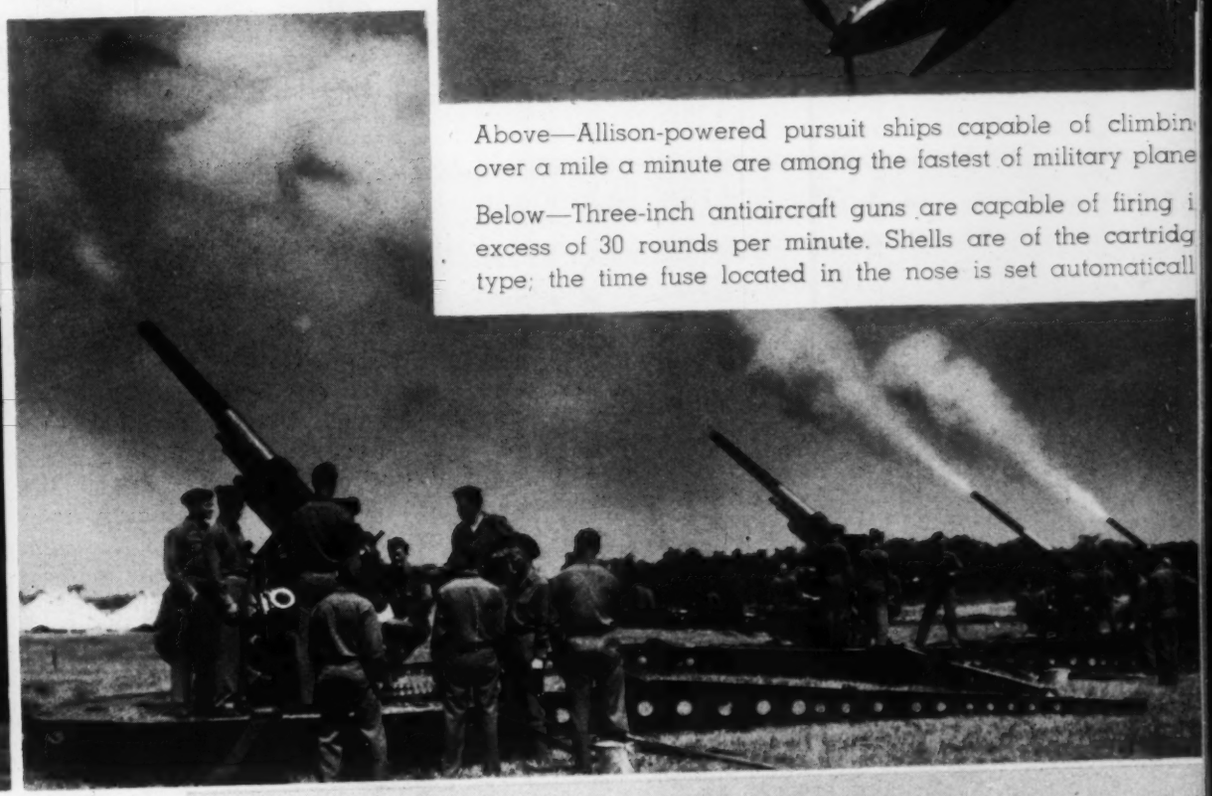
Army Equipment

U. S. Army Photographs)



Above—Allison-powered pursuit ships capable of climbin over a mile a minute are among the fastest of military plane

Below—Three-inch antiaircraft guns are capable of firing i excess of 30 rounds per minute. Shells are of the cartridg type; the time fuse located in the nose is set automaticall



ction apparatus form the nucleus of
"Ears" locate planes approximately
ng of light beam

gun is used also for 8-inch howitzer.
before firing. Shell weighs 95 pounds

f motorcycles make them valuable for
ement of small numbers of troops

imeter and a number of smaller guns
the Army's land combat vehicles

MACHINE DESIGN *Editorial*

"Send Us More Engineers!"

ALL indications point to the probability we are faced with a long war. An analysis of forecasts from what might be considered the most authoritative sources leads to the belief that a period of three to five years will be needed before hostilities can be brought to a successful conclusion.

The demand for men, particularly for engineers, unquestionably will be felt with increasing stringency during that time. Many designers whose work in the development of machines might well be of inestimable value to the country have already volunteered for service in the armed forces, and others have been called through the draft or by virtue of being members of the reserve.

Some of these men probably will be returned by the army to their regular line of work but—the need being what it is in this "machine" warfare—there will not be nearly enough engineers to go around. It behooves draft boards to use the utmost discretion in passing men for service. At the same time, engineers already engaged in vital work should continue in their task of supporting to the utmost of their ability the men in the front lines.

This thought applies similarly to students of high caliber in engineering colleges, many of whom will feel the urge to join the forces on graduation. The wishes of the individual play their part, but it is to be hoped that those who feel they must go will first make doubly certain that wherever they may be their engineering background will be utilized to the full in the service of the nation.

April Supplement

WHEREVER there's a machine there obviously is a drive—and a control. It is for this basic reason that MACHINE DESIGN'S readers welcome the appearance of the annual supplement on drives and controls published each year as a section of the April issue.

Previous editions of this supplement have been devoted to problems of transmission confronting designers of all classes of machines, including domestic, business and other types that are more or less curtailed under present conditions. Drives and controls embodied in armament equipment, in those machines utilized in its production, and in other machines identified with the nation's war program will, however, receive major emphasis in the forthcoming supplement. Such coverage is in complete agreement with the magazine's current policy of putting "first things first" in disseminating information of timely value to engineers responsible for design of machines.

L. E. Jermy

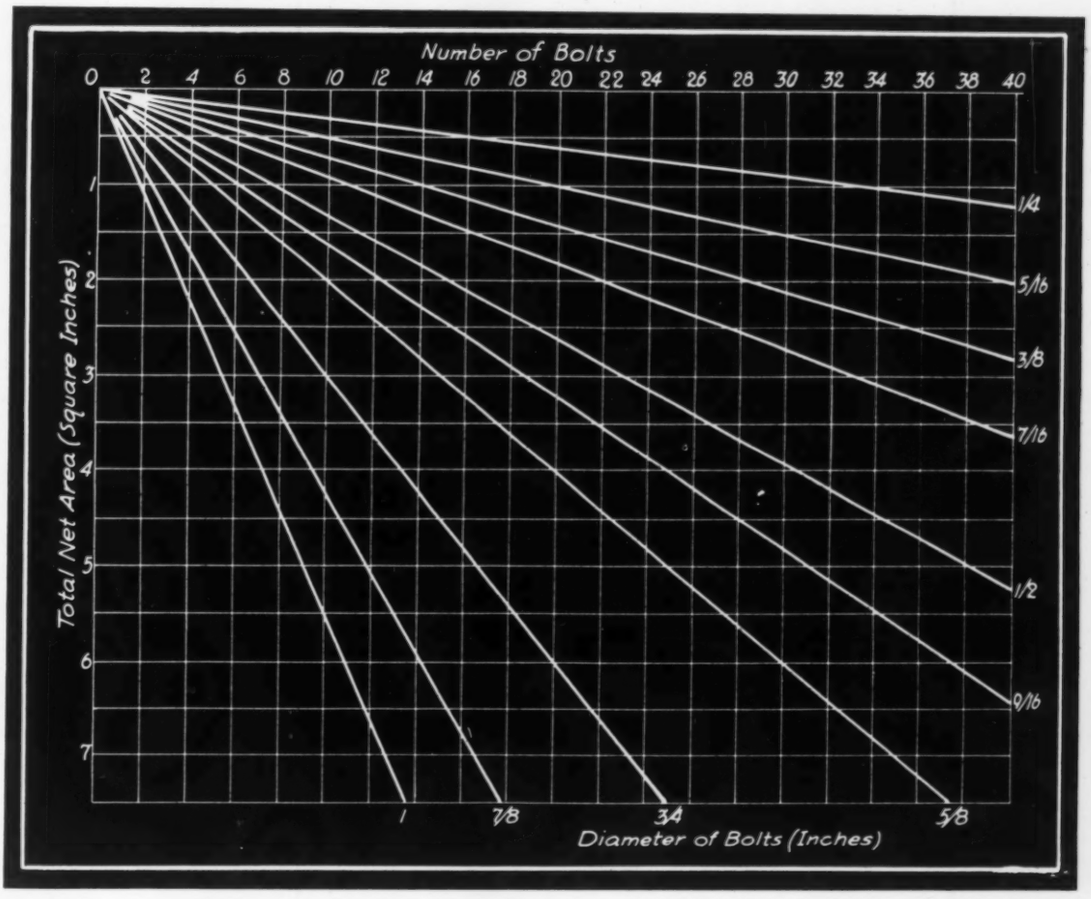
Selecting Size and Number of Bolts in Tension

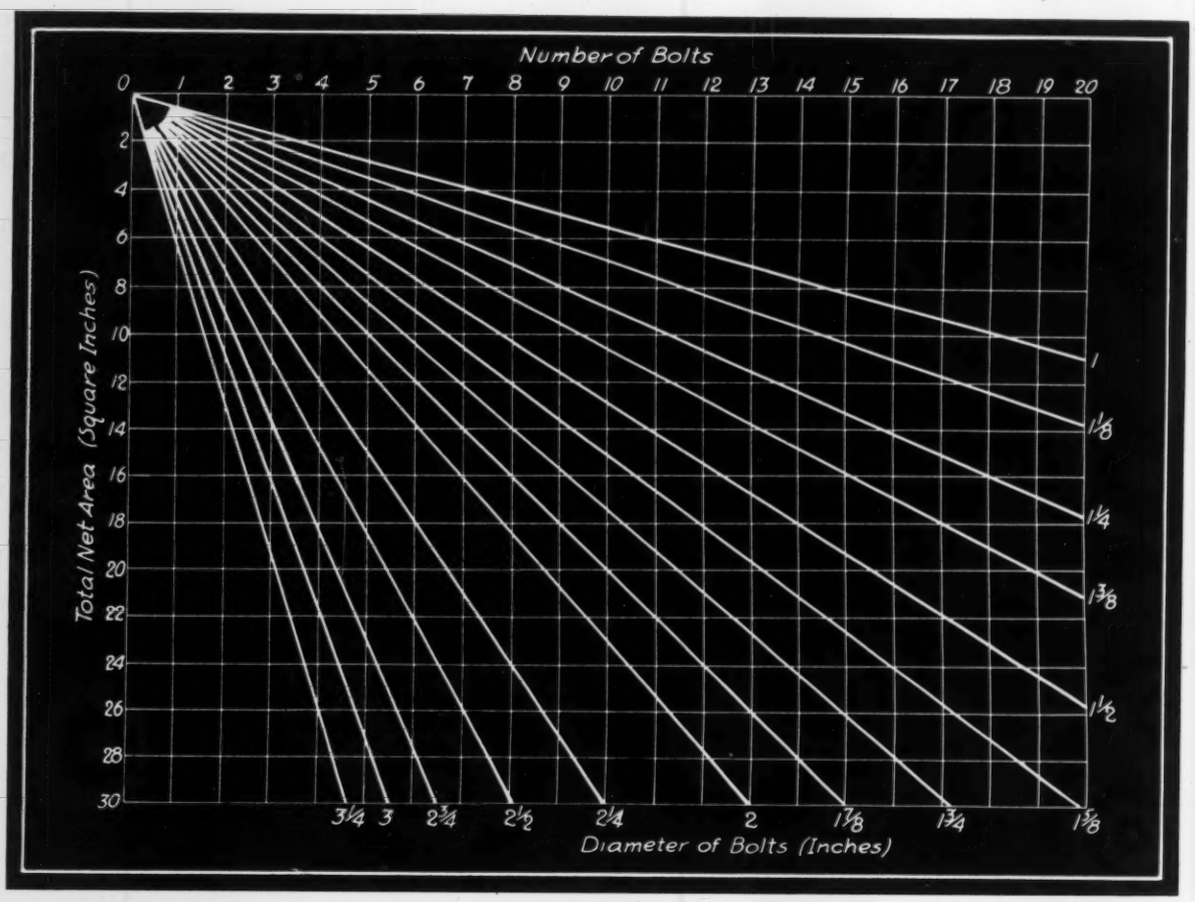
James P. Doolan

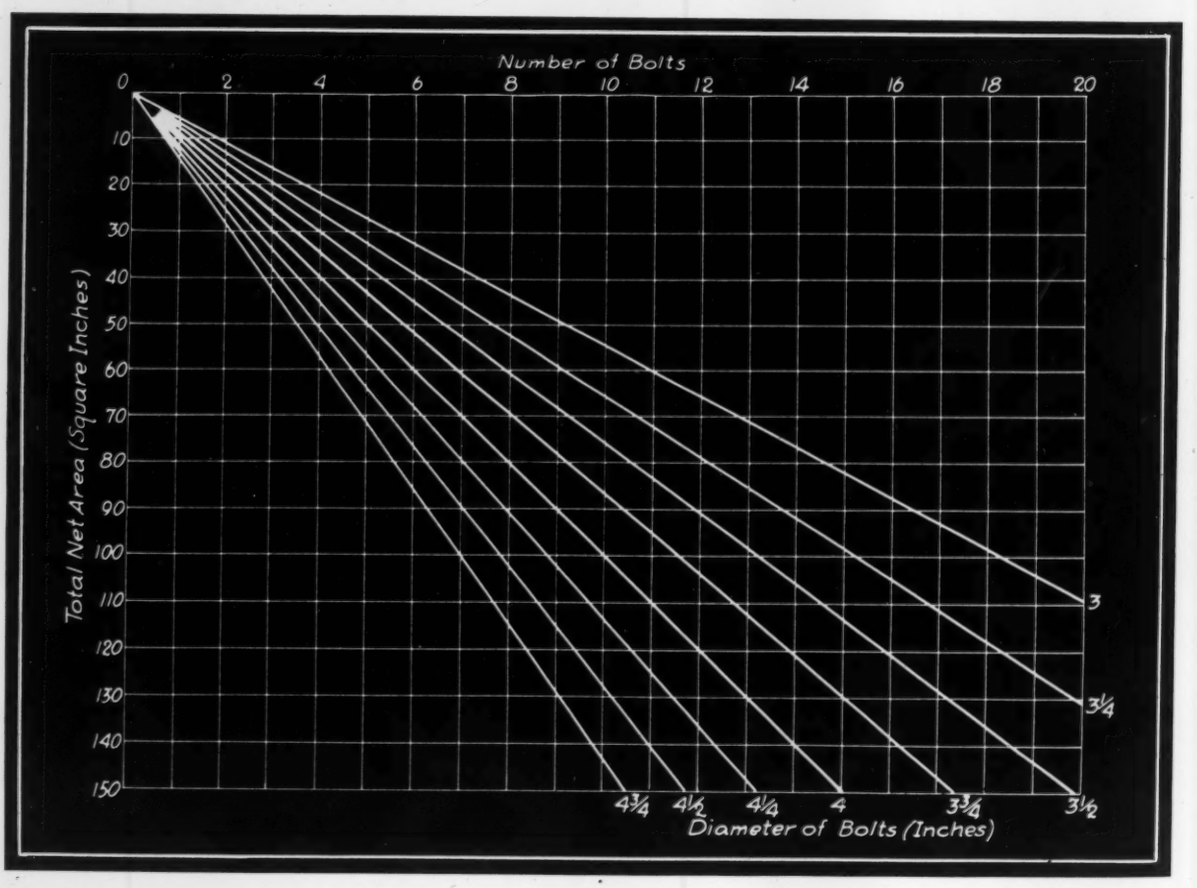
Timken Roller Bearing Co.

IN the design of machine parts wherein the load is carried by a number of bolts in pure tension, the actual number of bolts of a given size required to provide adequate cross-sectional area to support the load constitutes a time-consuming calculation. The following three charts are pre ented to obviate the necessity of such calculations.

Each diagonal line radiating from the upper left-hand corner represents a nominal bolt size (bolt diameter). The ordinate on the left is graduated in square inches of net area and the upper abscissa in number of bolts. For example, 20 bolts of a nominal size of ⅝-inch have a net area of 4 square inches. Also, if a given load requirement demands a net bolt area of 5 inches, this may be provided safely by 10 1-inch bolts, 12 ⅞-inch bolts, 18 ¾-inch bolts, 26 ⅝-inch bolts, etc.



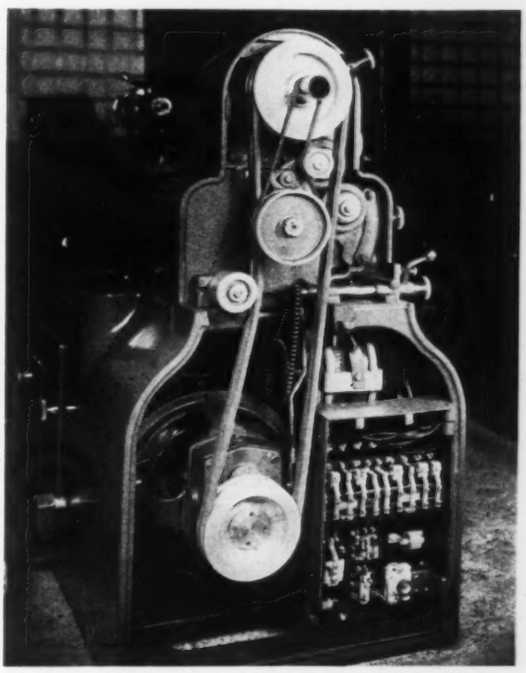

Number of Bolts
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Total Net Area (Square Inches)
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
1
1⅛
1¼
1⅜
1½
1⅝
3¼ 3 2¾ 2½ 2¼ 2 1⅞ 1¾ 1⅝
Diameter of Bolts (Inches)


Number of Bolts
0 2 4 6 8 10 12 14 16 18 20
Total Net Area (Square Inches)
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
3
3¼
4¾ 4½ 4¼ 4 3¾ 3½
Diameter of Bolts (Inches)

Applications

of Engineering Parts and Materials

Need for Change Gears Obviated

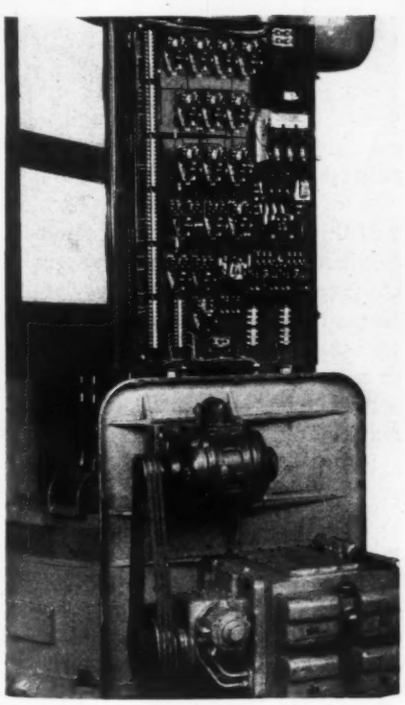


SATISFACTORY operation over a wide range of speeds is an absolute essential in lathes, particularly those intended primarily for use in toolrooms. In the Monarch lathe illustrated an infinite number of spindle speeds over a range up to 2500 revolutions per minute is achieved by an all-electric adjustable speed drive developed by the Reliance Electric & Engineering Co. Complete range of speed is obtainable by means of adjustments of a tandem rheostat controlling the speed of the direct-current lathe motor.

Compactness of the drive is evidenced by the illustration. The three-horsepower motor belt-connected to the lathe, a speed-adjusting rheostat, master lever, and the complete control panel containing forward and reverse contactors, all are concealed within the base of the lathe.

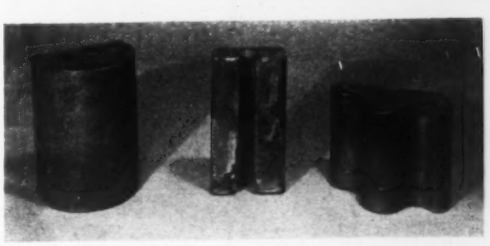
Thinks for Itself

CONSTITUTING a radical departure from conventional machines for chambering barrels of rifles and machine guns, the Krueger machine is capable of producing forty barrels per hour. The complete drive and control system includes four motors and five solenoid-operated hydraulic valves. Nine working stations and one loading station are used, the machine automatically indexing after each operation. The brains for directing and safeguarding the machine operations, developed by the Clark Controller Co., are centrally located in one control box affixed to the rear of the machine, readily accessible for adjustment, replacement and maintenance.



Cuts at High Speed

REFINEMENTS, in the application to oxyacetylene cutting tips, of the divergent orifice principle long used in the steam nozzles of turbines effect a large increase in the jet velocity of the cutting oxygen stream. This results in a 20 to 30 per cent increase in cutting speed. Illustrated are pieces cut with Airco equipment from an alloy steel block used in the construction of army field guns. The increased jet velocity results in a narrower kerf, better surface finish throughout the entire depth of the cut and, more important, reduces the angle of lag of the cutting stream, decreasing the shape tolerances.



Professional Viewpoints

MACHINE DESIGN welcomes comments from readers on subjects of interest to designers. Payment will be made for letters and comments published

" . . . cold rolling increases strength"

To the Editor:

This refers to the stimulating article by J. O. Almen under the title "Temper Theory with Experience," in your December 1941 issue.

One or two points which confuse me merit comment. First, the title under *Fig.* 6, "Internal Stresses Induced by Cold Rolling Reduce Fatigue Strength", should read "Surface Compression Induced by Cold Rolling *Increases* Fatigue Strength." The correction is then in line with the author's comment in the text.

In the first paragraph on Page 75 "*Fig.* 4 shows an SN diagram," this should read *Fig.* 5. Also, "General form suggested in *Fig.* 6", should be "General form suggested in *Fig.* 4."

The present reader hopes to hear from other readers commenting on other points of interest in this article.

—ROBERT E. BRUCKNER

Mr. Bruckner is right. We regret the occurrence of these errors. In line with the correction to the caption of *Fig.* 6, the caption for *Fig.* 7, reading, "Plated coatings affect fatigue strength in a manner similar to rolling," should be changed to, "Plated coatings reduce fatigue strength."—ED.

". . . creep characteristics of plywood"

To the Editor:

We compliment you on the excellent manner in which you treated the subject of plywood in your December number. Might we mention that the "creep" characteristics noted in the table on Page 54 can hardly be 15 per cent in actual dimensions, or 1½ inches per 10 inches? Some error may have inadvertently crept in here, perhaps in the position of the decimal point.

Still further, on Page 128, phenolics are not used in assembly work because of their *high* heat requirements, 230-300 degrees Fahr., while ureas can be used at 70-80 degrees, but are improved in durability by 130-150 degrees Fahr.

We feel that such articles cannot but be beneficial.

—THOMAS D. PERRY
The Resinous Products & Chemical Company

Referring to the creep characteristics, the table mentioned shows plastic flow in per cent for birch and poplar. For the tests, the specimens (bonded with three layers of Tego films between plys) were subjected to maximum fiber stress of 2000 pounds per square inch for 15 minutes at 125 degrees Fahr.—ED.

" . . . uses plywood for gliders"

To the Editor:

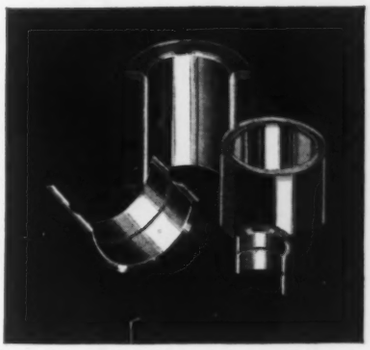
Recently the navy department announced the award of contracts for the manufacture of experimental gliders which has again attracted wide attention to the possibilities of plastic-bonded plywood. Included in the contracts are twelve-place troop carrying gliders.

The general lines of this glider, whose overall dimensions approximate those of the Douglas DC-3, originally were laid out by the engineering offices of the Naval Aircraft Factory in Philadelphia, under the direction of Commander R. S. Barnaby, who is also head of the Soaring Society of America. All subsequent engineering details are being worked out by Allied Aviation Corp., including detailed wind-tunnel testing of the final design in a seven-foot wind tunnel. As soon as the exact design details have been frozen, the molds for the various parts of the gliders will be commenced.

In the construction of these gliders the Navy has emphasized that they shall be built, insofar as possible, from nonstrategic materials. Molded plywood, for this reason, is being used increasingly and it is expected that with the exception of heavy bombers and large commercial aircraft, planes of all types will be made completely of this material.

The type of construction, however, is not new. Research and chemical advances in the past few years have simply culminated the work which

EXPERIENCE . . . *to guide*
FACILITIES . . . *to produce*
ABILITY . . . *to serve*



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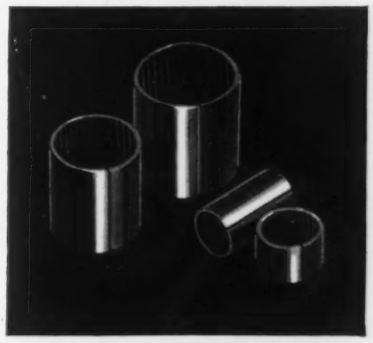
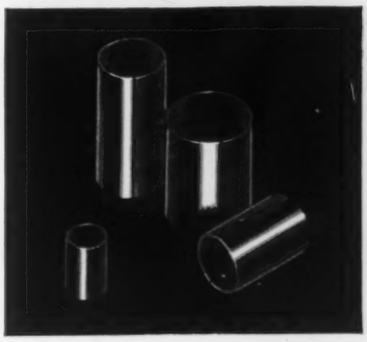
Write for your copy of the Fundamentals of Sleeve-Type Bearings, a handy file folder containing a wealth of information on Bearings and their applications. There is no obligation.





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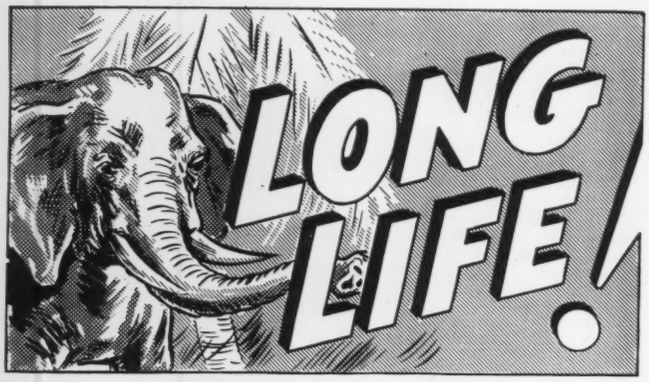

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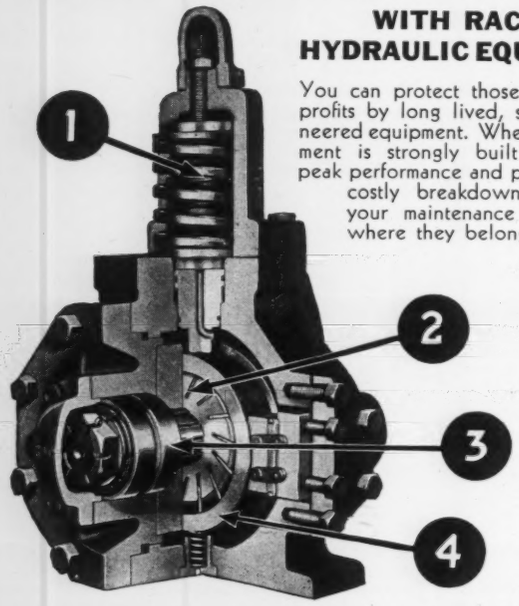

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began fourteen years ago when the Lockheed Vega, a plane with a molded casein-glued plywood fuselage, was produced. Production methods today are basically the same as used by Vega, except that present molds are constructed of wood, whereas previously concrete or metal was used.

Principal difference between the new and the old molded plywood lies in the type of plastic, or glue, used. Both systems employed fluid pressure and also heat applied to the resin or glue-coated veneers placed against properly slotted and contoured molds. The "cooking" process then molds the veneers into a single homogeneously bonded unit. This plywood is not only absolutely waterproof, mold-proof and insect-proof, but the bond between the plies is stronger than wood itself and weight-for-weight, plywood is stronger than metal.

A plastic in itself lacks proper tensile strength. It is hard, however, and therefore will absorb high shear and impact loads. As an adhesive, it grasps tenaciously when used as a bond. Hence, plastic is suitable in a stressed and loaded structure only when a filler agent, such as cloth or wood, is used and thereby becomes a bonding agent supporting fibers of complex structures, transmitting a load from one to the other. Because of its favorable weight-strength ratio, wood is a practical filler for aircraft structures and veneers therefore can easily be used.

—BURNHAM LITCHFIELD, *Vice Pres.-Gen. Mgr. Allied Aviation Corp.*

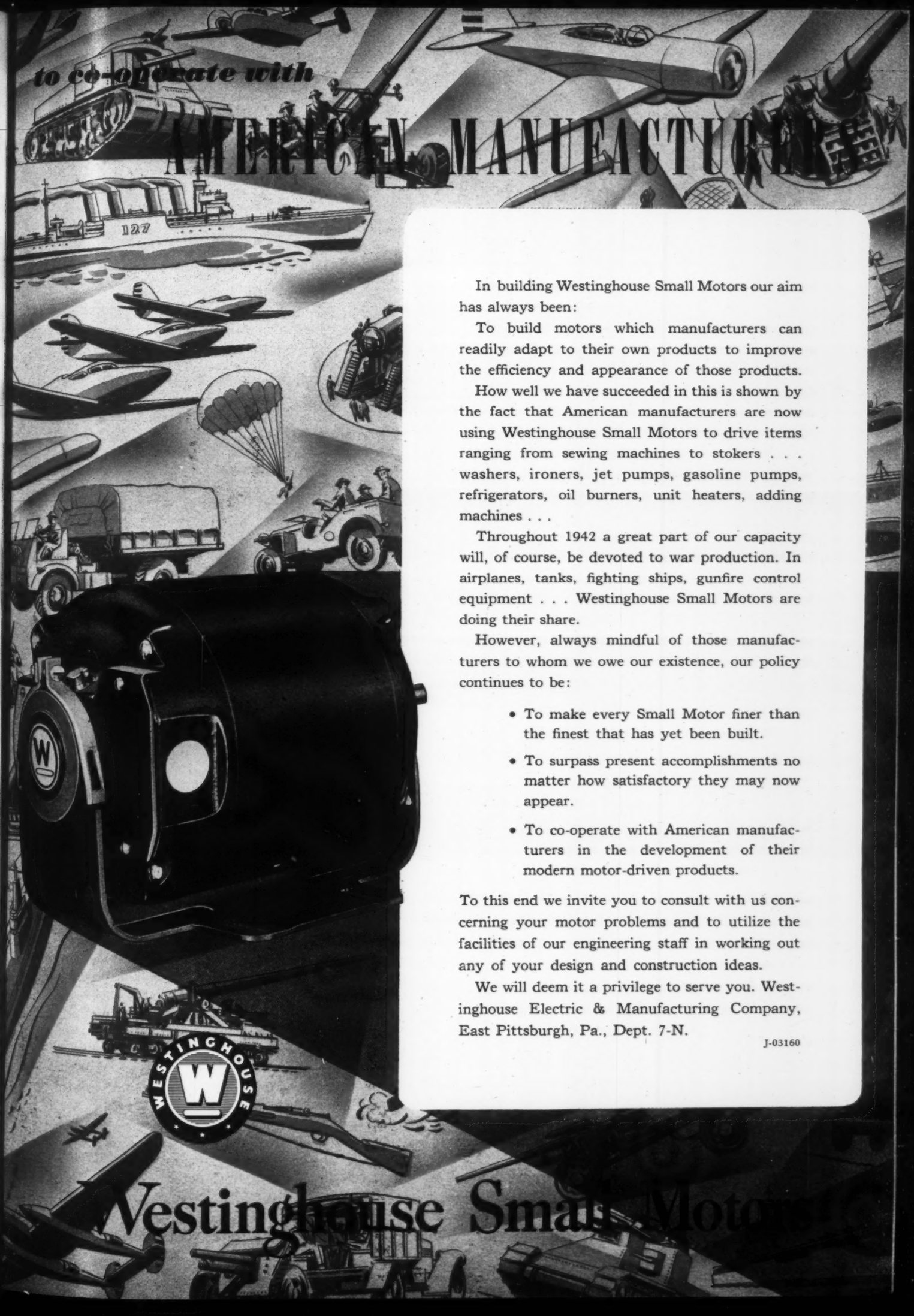
" . . . plywood requires further research"

To the Editor:

The term, "plastic-bonded plywood" is not sufficiently specific to define accurately which type of plywood is under consideration, as this general term might be interpreted to include not only the new synthetic resin adhesives but also the casein and the blood albumen, which in themselves may also be termed plastics. The modern, synthetic resin-bonded plywood, with which the aircraft manufacturer is particularly interested, is primarily one in which the synthetic resin is of such a character as to be impervious to bacteria and fungus attack, and substantially impermeable to moisture. These qualifications eliminate the use of casein and blood albumen as adhesives.

Although thermoplastic adhesives serve many useful purposes in industry, it is not felt that they are entirely satisfactory for aircraft, due to the large variation of their physical properties with temperature. In this regard it should be borne in mind that aircraft must be designed to operate between temperatures of −70 to +160 degrees Fahr. The lower temperature limit is attained at low altitudes in the tropics and includes the effect of the radiant heat of the sun. A majority of aircraft plywood is, therefore, bonded with synthetic

(*Concluded on Page* 160)



In building Westinghouse Small Motors our aim has always been:

To build motors which manufacturers can readily adapt to their own products to improve the efficiency and appearance of those products.

How well we have succeeded in this is shown by the fact that American manufacturers are now using Westinghouse Small Motors to drive items ranging from sewing machines to stokers . . . washers, ironers, jet pumps, gasoline pumps, refrigerators, oil burners, unit heaters, adding machines . . .

Throughout 1942 a great part of our capacity will, of course, be devoted to war production. In airplanes, tanks, fighting ships, gunfire control equipment . . . Westinghouse Small Motors are doing their share.

However, always mindful of those manufacturers to whom we owe our existence, our policy continues to be:

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- To surpass present accomplishments no matter how satisfactory they may now appear.
- To co-operate with American manufacturers in the development of their modern motor-driven products.

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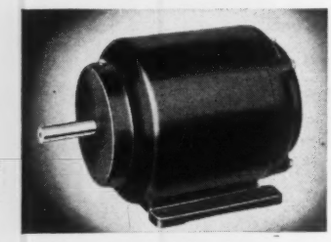
We will deem it a privilege to serve you. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

J-03160

New PARTS AND MATERIALS

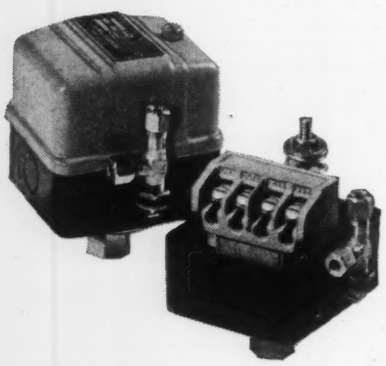
"Streamlined" Integral Motors

COMPACT, integral "streamlined" polyphase motors, manufactured by The Ohio Electric Mfg. Co., 5900 Maurice avenue, Cleveland, are being offered with the terminal box at the bottom, or at any other angle around the circumference. This feature as well as the fact that the motors are smaller in diameter and length than the standard NEMA motor of similar rating make the motors attractive to machine builders. The motors are built in a frame 8-inches in diameter by 10⅝ inches long, and in sizes ½ to 2 horsepower in all standard speeds.



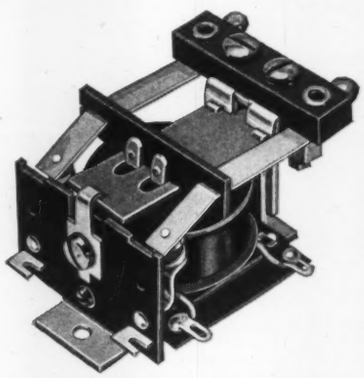
Pressure Switch for Compressors

ESPECIALLY designed for use with intermediate size air compressor motors, the class 9213 pressure switches, announced by Square D Co., 6060 Rivard street, Detroit, are two-pole devices, with a pressure limit of 200 pounds and 15 to 40 pounds differential. The terminal block is of porcelain, and plainly marked screws are in an upright position for quick wiring. Contacts are similar in size to the type used in large contactors, inspection being accomplished with minimum of effort. Actuating diaphragm is a high-grade fabric impregnated with a special rubber. An oil-resisting diaphragm can also be supplied, if desired. Slip-on cover of the switch is gray enamel, with the lower portion being black enamel. Interior parts are cadmium-plated to prevent corrosion. The switch can be obtained up to 2 horsepower, single phase, alternating current, and up to 3 horsepower, polyphase, alternating current. Voltage ranges up to 550.



Vibration-Resistant Relay

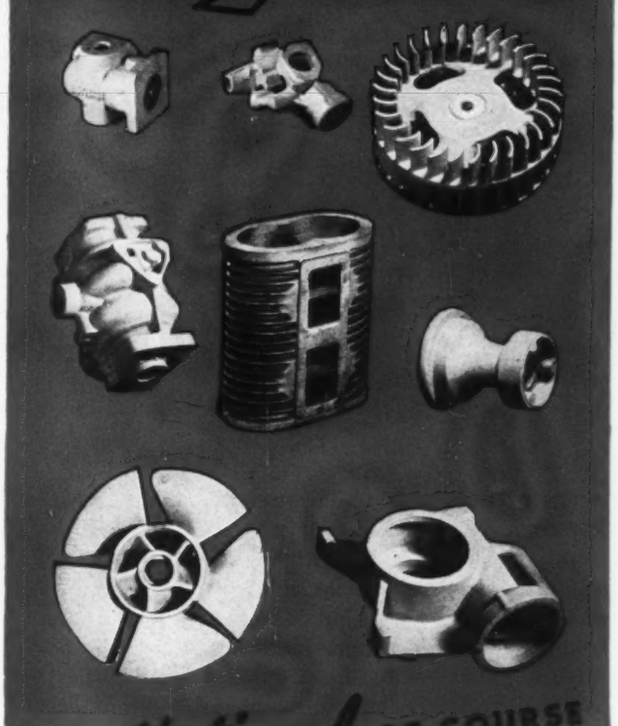
COMPACTLY constructed, a new series of vibration resistant relays have been brought out by Guardian Electric Mfg. Co., 1621 West Walnut street, Chicago. This relay is exceptionally resistant to vibration, and has application in such fields as aircraft, generator mountings, etc. Vibration resistance is achieved largely by careful counterbalancing of armature assembly and is due in no small degree to compact design of contact assemblies and its generally sturdy and scientifically balanced construction. The relays are entirely insulated from ground with insulation withstanding a minimum of 1500 volts. Field piece and armature are of annealed magnetic iron. Tinned, phosphor bronze blades carry heavy, fine silver points. All contacts are connected to tinned solder lugs. Contact combinations up to double pole, double throw are available, with contact capacity up to 12.5 amperes per pole, measured at 110 volt, 60 cycle, non-inductive alternating current. Con-



GREAT CASTINGS OF YESTERDAY

★ Perhaps one of the most duplicated castings in history is that of "The Thinker." From a model made by the famous French sculptor, Auguste Roden, The Thinker was first cast in bronze. Since that time it has been reproduced in many sizes and cast in many different metals.

Great ALUMINUM CASTINGS OF TODAY



BY National OF COURSE

Size alone does not necessarily decide quality in castings. Here at National there is a constant flow of quality castings that weigh less than one pound each—some as light as a fraction of an ounce. Then again we are turning out castings weighing over 3,000 pounds. The same skill and craftsmanship go into all National Aluminum Castings.

INDUSTRY HAS OPENED THE THROTTLE!

WE pledge ourselves to work harder—willingly and cooperatively meet increased demands to the best of our ability.

Recently we added a complete new plant with approximately some 200,000 sq. ft. It has been equipped with all modern equipment. And most important of all . . . our men in the shop have pledged their all-out willingness to turn to and produce more.

By those behind the first line of defense, THIS WAR WILL BE WON. We will do our part and cheerfully carry our share of the burden.

• • • —

In addition to T-1 Aluminum Alloy castings that have physical properties that meet the specifications of many commonly used heat-treated castings, we also produce heat-treated TENUAL aluminum castings.

Alloys produced in accordance with Army, Navy, S.A.E. and A.S.T.M. specifications.

T-1 ALUMINUM ALLOY

TENSILE STRENGTH 30,000 lbs. minimum
Elongation 6% WITHOUT HEAT TREATMENT

SPECIFICATIONS

Army Air Corps 11324
Navy Aeronautical M-397 Classification AL-31
Army Air Corps 11325
Navy 46A1 (INT) Class 6

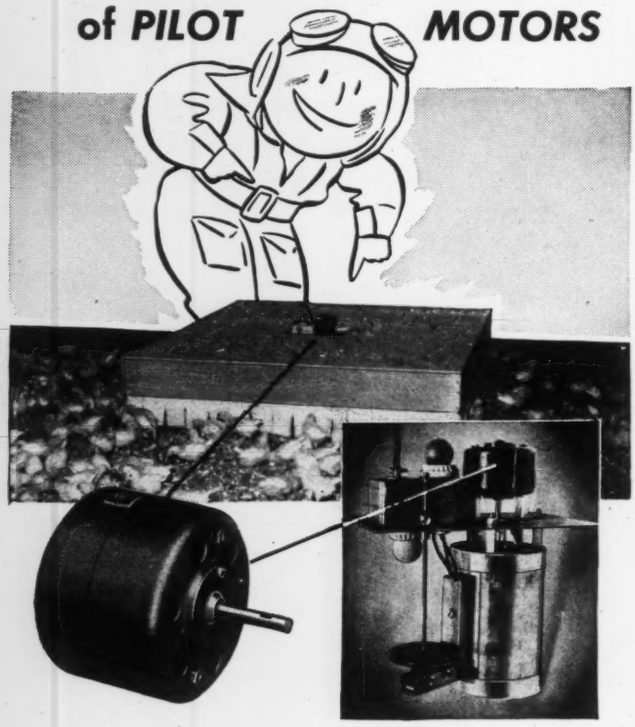
THE NATIONAL BRONZE AND ALUMINUM FOUNDRY CO.

Twin Plants, CLEVELAND, OHIO

NEW YORK, 111 Broadway • DETROIT, Stephenson Bldg. • CHICAGO, 188 W. Randolph • LOS ANGELES, 405 S. Hill

Pilot Dan the Motor Man

Finds that Healthy Chicks Bring Bigger Checks to Users of TRUMBULL ELECTRIC BROODERS thanks to the Dependable Performance of *PILOT* MOTORS

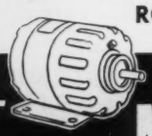


THE BROODERATOR, Electric Poultry Brooder manufactured by the TRUMBULL ELECTRIC MFG. CO., of Plainville, Conn., is solving the problem of safe, convenient, low-cost chick raising for hundreds of Poultrymen. Pilot Motors, because of their reputation for dependable, low-cost operation are used *exclusively* as power drives in all Trumbull Brooderators.

BROODERS or BLOWERS... or wherever there's a need for a Fractional H.P. Motor then there's a job for *PILOT!*

Pilot Shaded-Pole, Induction Type Motors are available in Fractional H.P. ratings from 1/500th to 1/15th. Write today for Bulletin P-2341 giving complete information about these dependable, low-cost Motors.

F. A. SMITH MFG. CO.
201 DAVIS ST. ROCHESTER, N. Y.

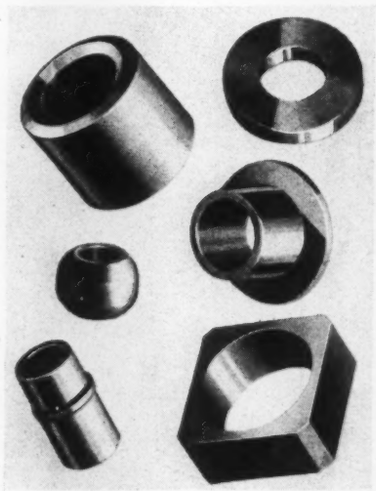


Pilot MOTORS
FRACTIONAL · H · P · MOTORS

tact rating for aircraft use is 8 amperes at 24 volts direct current. Other voltages and contact combinations are available. Overall dimensions of the relay are 2½ x 1 9/16 x 1⅝ inches. Weight is 5 ounces.

Porous Iron Bearings

POROUS iron bearings have been added to the line of self-lubricating bronze bearings manufactured by The Keystone Carbon Co. Inc., Saint Marys, Pa. Introduced to conserve copper, the new porous iron bearings are stronger than the porous bronze bearings, and are interchangeable in most applications. Made from powdered iron which is molded to desired size and shape, then baked, and finally saturated with oil, the bearings have an



average porosity of 25 to 35 per cent, enabling them to store a large amount of oil. In many cases this oil reserve lasts the entire life of the application. However, additional lubrication is recommended for heavy-duty or continuously operating units. The new bearings have a low coefficient which, together with the self-lubricating qualities, prevents excessive temperature, speed reduction, noise and scoring of shaft. Supplied in both standard and special shapes, the bearings are molded to close dimensional tolerances so that no redesigning or special engineering is required.

Motors for Aircraft Service

DESIGNED to meet aircraft service requirements, a complete line of fractional-horsepower motors has been announced by General Electric Co., Schenectady, N. Y. These direct-current motors, designated as Types BA-25, -40, -50, and BC-21 and -31, can be furnished as series, compound, or shunt-wound motors to meet varied applications. Ratings range from 1/200 horsepower at 7500 revolutions per minute, continuous

Timely information about metals... CATALOGUED for your convenience

Specific answers to many of your questions about the selection, fabrication and uses of Nickel alloys are available to you quickly from our files.

This fund of helpful information we have gathered, checked and condensed into convenient printed form. The graphs, charts and shop guides are especially useful to men handling new materials or performing unfamiliar operations . . . and to new employees. This literature is available on request.

You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. These engineers are offering timely suggestions to many vital industries during the present emergency.

Why not drop us a card asking for list of available literature. Your request for the assistance will receive prompt attention.

NICKEL

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

Blueprints

KOH-I-NOOR

THERE IS NO TIME TO SPARE in producing any of today's requirements. Readable blueprints must be rushed to production departments without delay and the fabrication of parts started.

For any important task, KOH-I-NOOR DRAWING PENCILS have long been the unanimous choice of discriminating draftsmen. You will most certainly approve their smooth, long wearing qualities and their ability to produce well defined, light impervious lines, resulting in clearer, more legible blueprints.

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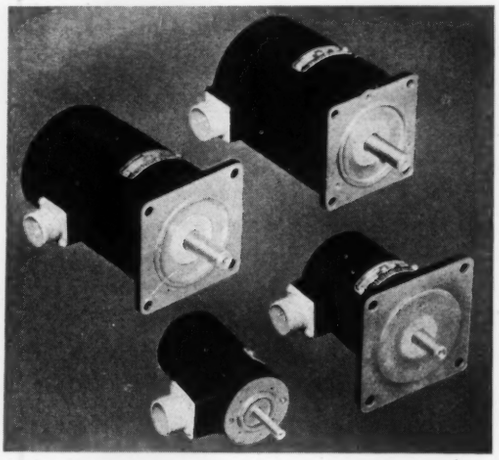
PENCIL COMPANY INC.
373 FOURTH AVENUE · NEW YORK

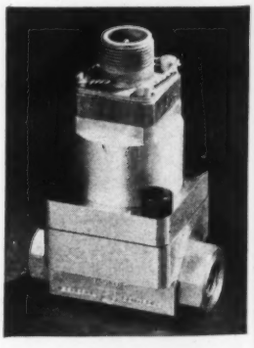
operation, open type, to 7 horsepower at 7500 revolutions per minute, totally enclosed, 1 minute intermittent duty. Frames are of aluminum for light weight, or magnesium casting where weight must be held extremely low. Other construction features include bolted-in pole pieces, precision bal-



ance, all ball-bearing construction and standard Air Corps flange mountings in styles II, III, and IV. Standard shaft extensions are plain but can be obtained with cut spline or other special features. The motors are equipped with AN-3102 connectors, but leads can be brought out through side of motor and held in place by rubber plug. All types are available, for either grounded or ungrounded wiring systems.

Electric Valve Announced

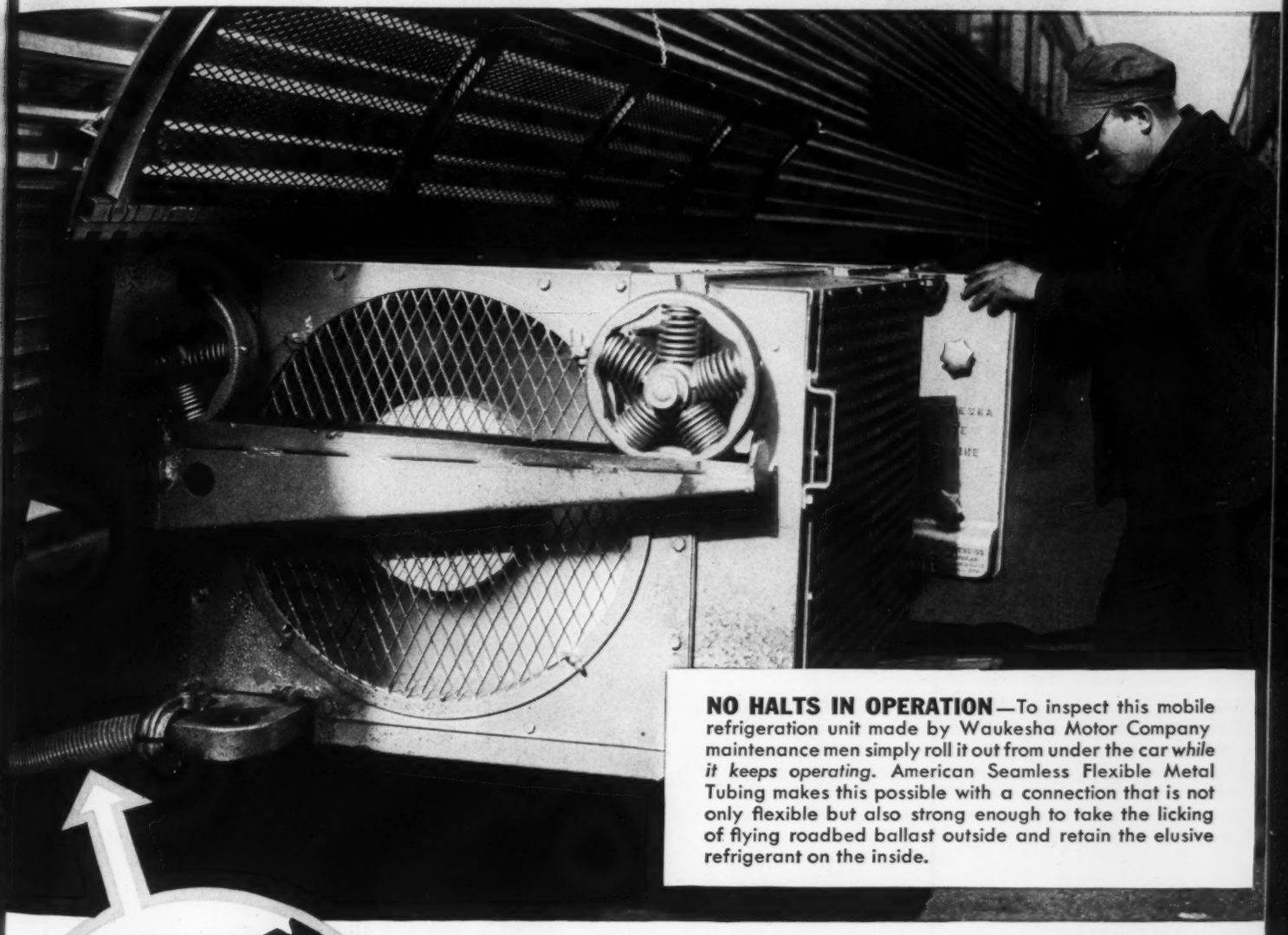
FOR positive valve operation on mobile equipment and vibrating machines, General Controls Co., Glendale, Calif., is offering its new series of electric valves designated as Series PV. Valve can be used for numerous applications including airplanes, buses, trucks, tanks, tractors, railroad cars, ships, boats, machine tools, etc. These valves, new in design, should not be confused with modified stationary valves or alternating current type valves. The main feature in the design was to provide positive operation regardless of vibration, movement or substantial increases in acceleration. Designed for compactness and low weight, the valves are of two-wire, current-failure type and will handle all kinds of liquids, gases, and vapors, including refrigerants, greases, gasolines, alcohol, anti-icing fluids, etc., under pres-



HERE, FLEXIBILITY HELPS SET A RECORD

Manufacturer of this mobile refrigeration unit says:

"The performance records of our units . . . are infinitely better than they would be if this roll out feature were not made possible by your flexible tubing."



NO HALTS IN OPERATION—To inspect this mobile refrigeration unit made by Waukesha Motor Company maintenance men simply roll it out from under the car *while it keeps operating.* American Seamless Flexible Metal Tubing makes this possible with a connection that is not only flexible but also strong enough to take the licking of flying roadbed ballast outside and retain the elusive refrigerant on the inside.

FLEXIBLE METAL→ OUTSIDE ARMOR
←BRAIDED WIRE JACKET
←ONE PIECE CONTINUOUS SEAMLESS TUBING
←SECTION VIEW - NO SEAMS NO WELDS, NO PACKING

There's a strength advantage in American Seamless Flexible Metal Tubing as well as flexibility. Riding beneath this fast moving streamliner, roadbed ballast impinges forcefully on the connector's exterior. But, all-metal construction effectively withstands the rigorous service.

This combination of strength and flexibility has dictated the use of American Flexible Metal Hose and Tubing throughout industry as dependable connectors for the conveying of oil, steam, liquids, solvents and gases.

Naturally, your government has recognized the advantages of American Metal Hose. Today, it is working almost exclusively for our national war effort, directly in giant bombers and indirectly in helping to maintain uninterrupted production in war-vital plants.

42196

American Metal Hose

ANACONDA
from mine to consumer

AMERICAN METAL HOSE BRANCH OF THE AMERICAN BRASS COMPANY
In Canada: Anaconda American Brass Ltd., New Toronto, Ontario
General Offices: Waterbury, Conn. • *Subsidiary of Anaconda Copper Mining Co.*

NOPAK HY-PRESSURE, Balanced Hydraulic Operating Valve, available in 4 sizes, either by-pass or accumulator.

It's New!

IT'S EASY TO OPERATE!

NOPAK ..Hy-Pressure Balanced Hydraulic Valve

The NOPAK HY-PRESSURE Hydraulic control valve provides operating advantages never before available at hydraulic pressures over 500 pounds.... *It requires no more manual effort to operate than an automobile gear shift*—even at pressures of 1,000 lbs. and more....The *hydraulic pressure* inside of the valve is always *balanced in all directions.* As a result, the valve *never gets "pressure-locked"* in one position, to cause delays.... *Easy manipulation speeds up production, eliminates operator's fatigue.* . . . There is *practically no pressure-drop* between inlet and exhaust ports. Write for literature, now, on this important NOPAK development!

...ONLY *ONE* MOVING PART

Only moving part in this HY-PRESSURE Valve is the spindle . . . forged in one piece of nickel alloy, heat treated and hardened for strength and long life. Nothing to wear out or require maintenance.

GALLAND-HENNING MFG. CO.
2752 S. 31st Street • Milwaukee, Wis.
Representatives in Principal Cities

NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

A 3624-½A

sures from a fraction of a pound to 1500 pounds or more. They can be operated in any position, being packless and drip-proof. Application of these valves to airplanes saves weight and simplifies many tubing and piping arrangements.

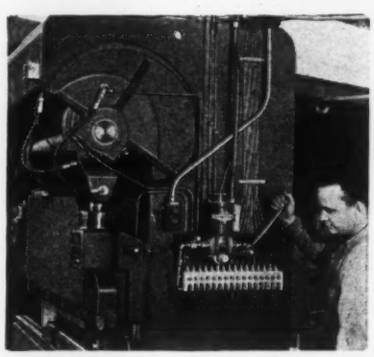
Packings of Synthetic Rubber

PACKINGS and other parts which are required to withstand unusual conditions are now being made of new synthetic rubber, produced by The Monarch Rubber Co., Hartville, O. By compounding this new synthetic rubber, the company has developed special shapes and sizes of packings and

other molded and extruded parts. These have exceptional oil resistance, flexibility and ability to seal pressures at extremely low temperatures, and other desirable qualities not available with usual rubber parts. For aircraft use and wherever there is a wide variation of temperatures, packings of this material are particularly desirable.

Centralized Lubrication System

EASILY installed, a new centralized system for lubricating all bearings is the latest addition to the line of Lincoln Engineering Co., 5701 Natural Bridge avenue, St. Louis. For wide use on industrial machinery of all kinds, this system consists of a number of injectors—one for each bearing to be lubricated, each connected to bearing by tubing or flexible high-pressure hose as required, and each individually adjusted to discharge re-



quired amount of lubricant. Injectors can be mounted singly or in manifold and are supplied

There is *no shortage of Torrington Needle Bearings* for priority applications . . . they can be delivered with the promptness you need to maintain your production schedules!

When the Needle Bearing was introduced eight years ago, design engineers in every field quickly recognized its unusual merits. Encouraged by the steadily rising sales that confirmed industry's growing acceptance of the Needle Bearing, Torrington began a program of plant expansion designed to permit wider utilization of the bearings' potentialities. With the beginning of defense activities, indications of still heavier demands provided the basis for further expansion, and today production is geared to meet the needs of the Victory program.

The Needle Bearing has already demonstrated its efficiency in countless industrial applications, where its small size, low cost, high capacity, ease of installation and lubrication have made possible improvements in product design and operation, or reductions in manufacturing costs. And today there is a still more important reason for the use of the Needle Bearing—its availability for *prompt* shipment on rush orders.

You can eliminate one source of production delays by planning *now* to incorporate the Needle Bearing in your designs. Torrington engineers will be glad to work with you in adapting the Needle Bearing's advantages to your specific problem. For full details write for Catalog No. 109.

NO SHORTAGE HERE!

THE TORRINGTON COMPANY
TORRINGTON, CONN., U. S. A. • *Estab. 1866*
Makers of Needle and Ball Bearings
New York Boston Philadelphia Detroit
Cleveland Chicago Los Angeles Seattle
San Francisco Toronto London, England

TORRINGTON NEEDLE BEARING

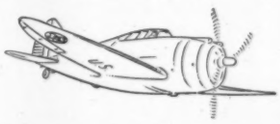
EFFICIENT OPERATION

Torrington Needle Bearings permit anti-friction construction at important points in A.C.F. passenger coaches, giving smooth, efficient operation. Needle Bearings contribute also to reduction in need of service attention, because of their long life and efficient lubrication.

THE A. C. F. MOTORS COMPANY

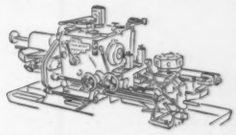
SAVINGS IN WEIGHT

Needle Bearings themselves are light in weight, and their simple design often permits additional weight savings through simplification of surrounding parts. These advantages are especially important in aircraft applications—for example, in Republic's P-43 "Lancer" pursuit plane.



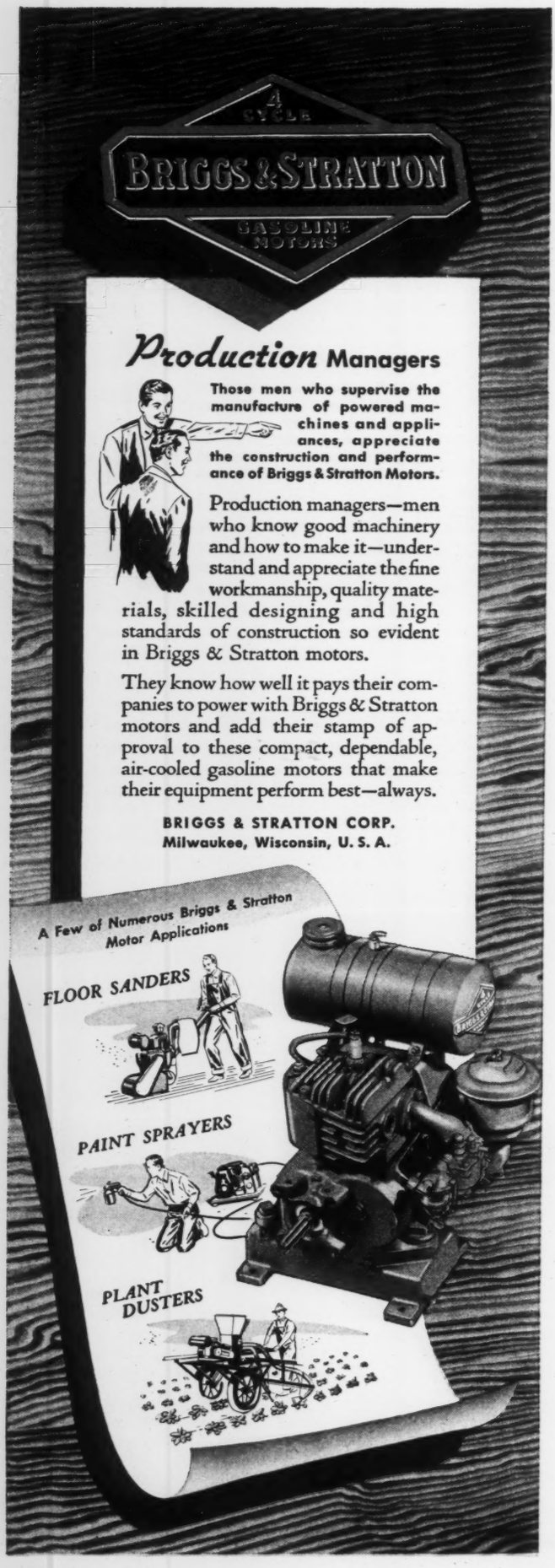
REPUBLIC AVIATION

LONGER SERVICE LIFE



Use of Needle Bearings at six locations on the power automatic chuck unit of Warner & Swasey's No. 2 Turret Lathe results in longer life of the unit, insures smooth operation as well. High capacity and small size of the Needle Bearing are additional advantages in this application.

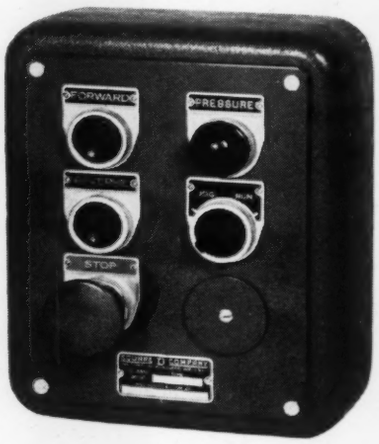
THE WARNER & SWASEY CO.


4 CYCLE
BRIGGS & STRATTON
GASOLINE MOTORS
Production Managers
Those men who supervise the manufacture of powered machines and appliances, appreciate the construction and performance of Briggs & Stratton Motors.
Production managers—men who know good machinery and how to make it—understand and appreciate the fine workmanship, quality materials, skilled designing and high standards of construction so evident in Briggs & Stratton motors.
They know how well it pays their companies to power with Briggs & Stratton motors and add their stamp of approval to these compact, dependable, air-cooled gasoline motors that make their equipment perform best—always.
BRIGGS & STRATTON CORP.
Milwaukee, Wisconsin, U. S. A.
A Few of Numerous Briggs & Stratton Motor Applications
FLOOR SANDERS
PAINT SPRAYERS
PLANT DUSTERS

with lubricant from a central pumping unit. Outstanding features of the system are the single lubricant supply line between the pumping unit and the injectors, the wide range of pumping units available, and the varied types of control. Pumping unit is a new 2 pound pump which can be easily mounted on the machine. Other pumping units with 30-pound capacity as well as pumps that handle lubricants direct from 100-pound and 400-pound capacity original drums are also available. The systems can be either electrically-operated with pushbutton, or entirely automatic with time clock.

Control Stations and Enclosures

DEMAND for greater flexibility of application of control stations and enclosures by machine tool builders has brought about the design of the new Class 9001, Type M pushbutton stations and enclosures, manufactured by Square D Co., 6060 Rivard street, Detroit. Ample protection against damage to control units is provided by the heavy cast-iron construction of enclosures, which are available for 3, 6, 9, 12 and 16 pushbutton, selector



switch, or pilot light control units. Each may be furnished as an assembled station or as an enclosure only, in which units from stock can be fitted to fill pertinent needs of the manufacturer. Closing plate assemblies are provided for unused openings in the cover plate. Gasket and steel cover plate are of cast iron, drilled to accommodate standard drip-tight control units. Case may be drilled and tapped for conduit entrance for five locations. Blue-gray enamel finish adds to the appearance of the new devices.

Leather Gasket Material

INTRODUCED by Armstrong Cork Co., Lancaster, Pa., a new fabricated leather gasket material has the natural advantages of leather without sacrifice of quality control, uniformity, etc. This ma-

Chrome-moly steels speed production and lower costs

A manufacturer of speed reduction gear pinions is taking advantage of two of the outstanding advantages of Chromium-Molybdenum (4140) steel — uniform hardening in heavy section, and excellent machinability at intermediate hardnesses.

Pinion and shaft are machined integral from a 4140 round oil quenched and tempered to about 150,000 p.s.i. tensile and 300 B.H.N.

Uniformity in hardness of the heat treated bar assures adequate strength in the shaft even though its diameter is only about half that of the pinion. This integral construction eliminates an assembly operation and makes for better performance.

Send for our free technical book, "Molybdenum in Steel". It contains helpful data on Molybdenum steels that may be of assistance in your own problems.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • CALCIUM MOLYBDATE

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TAYLOR FORGE

Forged and Rolled STEEL RINGS

ANY SIZE FROM 12" O.D. TO 100" O.D.

HERE at Taylor Forge your requirements for forged steel rings are handled with the skill and knowledge born of 40 years experience in the forging and rolling of steels and alloys. As the world's largest manufacturer of forged steel flanges, Taylor Forge has amassed the finest forging, rolling and machining equipment — the most complete and modern laboratory testing equipment — exceptional facilities for special heat treating to insure desired characteristics.

Inquiries are invited

TAYLOR FORGE & PIPE WORKS

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New York Office: 50 Church Street
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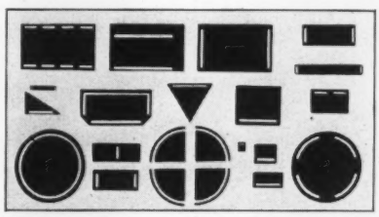
▶ Other Taylor Forge Products include: "WeldELLS" and related seamless fittings for pipe welding; forged steel flanges; forged steel nozzles and welding necks for boiler and other pressure vessel outlets; light wall spiral pipe; heavy wall electric-weld and forge welded pipe; corrugated furnaces, and similar forged and rolled products.

terial, known as No. 841, is recommended for sealing oil, water or gasoline, and for other general gasketing purposes wherever temperatures do not exceed 300 degrees Fahr., and where acids or alkalis are not encountered. Supplied in rolls and sheets in standard widths up to 48 inches, the tough and tear-resistant material is also available in shapes die-cut to specifications. It is compressible, has a high percentage of recovery and takes a minimum amount of permanent set. In addition, it is subject to a minimum of dimensional or other physical changes due to moisture, dryness, or temperature variation.

Dry-Disk Photocells

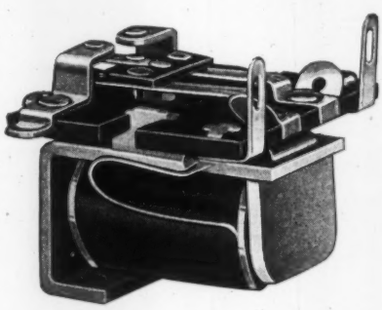
PHOTRONIC dry-disk photocells are now being supplied in a wide variety of sizes, shapes and characteristics to meet specifications, by the Photronic division, Weston Electrical Instrument Corp., 614 Frelinghuysen avenue, Newark, N. J. Such



specialties as multiple cell circuits on a common electrode are included. These cells can be furnished to meet exactly specifications as to output, resistance, spectral response, etc., regardless of quantities involved.

Midget Relay for Aircraft

SMALLER and lighter relays for aircraft and radio work have been developed to meet the increasing demand, by Guardian Electric Mfg. Co., 1621 West Walnut street, Chicago. Designed to give maximum control in minimum space, this



Series 195 DC midget relay has a maximum contact capacity of approximately 150 watts, measured at 110 volt, 60 cycle, noninductive, alternating current. In some of its present aircraft appli-

This new tracing cloth defies moisture stains and erasure scars

This new tracing cloth won't show perspiration stains or water marks—*holds pencil smudges and erasure scars at a minimum.* Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

For PHOENIX is ghost-proofed by a remarkable new process that defies moisture and gives you an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H lines show clearly, and reproduce sharply! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. Its new white color and increased transparency give you excellent drawing contrast and produce strong blueprints.

Put PHOENIX through your own drawing board test. See your K&E dealer, or write for a generous working sample and an illustrated brochure.

PHOENIX DEFIES MOISTURE GHOSTS . . .

Perspiration and water splashes on ordinary tracing cloth create "ghosts" which reproduce on blueprints. PHOENIX Tracing Cloth withstands actual immersion in water for fully 10 minutes at a time! *Perspiration and water marks will not stain it!*

PHOENIX LESSENS SMUDGE GHOSTS . . .

The new improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: Cleaner tracings and blueprints.

PHOENIX REDUCES ERASURE GHOSTS . . .

Ordinary tracing cloths become scarred when erased . . . erased spots produce ghosts on blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

K&E

Phoenix

REG. U.S. PAT. OFF.

TRACING CLOTH

for pencil *and* ink

EST. 1867

KEUFFEL & ESSER CO.

NEW YORK · HOBOKEN, N. J.

CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES

DETROIT · MONTREAL

Controlled

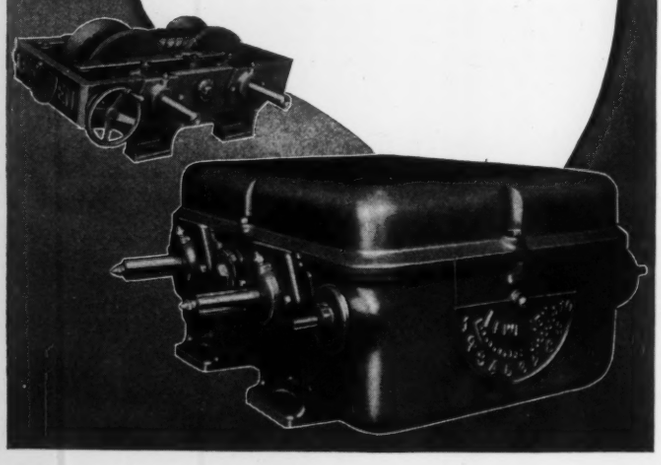
FULL SPEED AHEAD

TRUE ENOUGH, the watchword of the hour is SPEED. But, actually, machine speed must be controlled efficiently to step up production. This is a fundamental fact—proved today more than ever before. Thus, Lewellen Variable Speed Transmissions, Variable Speed Motor Pulleys and Automatic Controls assume a top role in providing a complete system of production control and regulation to our nation's industries. Lewellen engineers are constantly finding ways to adapt new applications of variable speed control to fixed-speed machines and to hundreds of machines using inefficient speed-control methods. Our engineers are specialists. We have no side-lines—no other interests than to help you solve your speed-control problems.

Call a Lewellen Representative or write us direct

LEWELLEN MANUFACTURING CO.

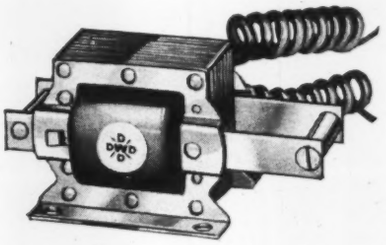
COLUMBUS, INDIANA



cations, the contacts have a non-inductive capacity of 3 amperes at 28 volts direct current. Maximum contact combination available is double pole, double throw. With a 2-watt coil and single-pole, double-throw contacts, in the de-energized position, the normally closed contacts will withstand vibrations of six times gravity, the normally open contacts ten times. In the energized position the contacts will withstand ten times gravity. Relay coil is available for any voltage up to 75 volts direct current. Maximum resistance is 3000 ohms. Average power requirement of the coil is 2.5 watts.

Solenoid of Laminated Type

OF LAMINATED type, a new solenoid manufactured by Dean W. Davis & Co. Inc., 549 West Fulton street, Chicago, is used for controlling production machinery, the operation of hydraulic valves, and many other industrial applications. Compact in design, with unusual sturdiness, it is



for constant or intermittent duty on alternating current, and is furnished with either push or pull type plungers. Field coil is paper section wound, taped and specially treated to be impervious to cutting oils. The solenoid measures 2 x 2 inches with a plunger stroke of ¾-inch, and can be had for any voltage. A minimum push or pull of 5.5 pounds at full line voltage and 3.75 pounds at 85 per cent of line voltage can be obtained.

Electronic Liquid Level Control

MODEL FL-2 liquid level control, produced by Lumenite Electric Co., 407 South Dearborn street, Chicago, has wide application for controlling level of water, syrup, oils, milk, soup, soap, acids, brine, chemicals, fruit juices, etc., in any type of container, open or closed. It is used in tanks, vats, kettles, boilers, pasteurizers, coolers or freezers, inasmuch as heat, steam vapors, foam, cold and frost, high or low temperatures have no influence on its function. This two-circuit control is complete for 115 volt or 230 volt alternating current, with two bare electrodes of stainless steel, 1 and 2 feet long, fitted with insulated mountings of Type A, and 50 feet of special lead-in wire. The ratings of the relay contacts are ¾ horsepower. When liquid contents of container make contact, or leave

ZINC IN WAR

Loading a gun with 3-inch shells. U. S. Navy photo

BRASS, BRASS AND MORE BRASS

The United States Army and Navy have no satisfactory substitute for brass shells and cartridges. Nor is there any substitute for the high grade zinc used in ordnance brass.

When shell charges are detonated, brass casings heat rapidly to expand and seal the gun breach; then in cooling quickly they shrink to permit easy ejection. It is questionable whether this action can be obtained with any other metal.

From a manufacturing standpoint, it is essential to use 30% of high grade zinc in shell brass to achieve the proper degree of ductility and formability. These properties are necessary to withstand the deep drawing operations employed in forming shell cases in automatic machines.

The fact that one shell of 5-inch diameter requires 18 pounds of brass is impressive. But when the millions of cartridge and shell cases for automatic rifles, machine guns, anti-aircraft and mobile artillery are considered, then the total zinc tonnage required for the Victory Program can be more fully appreciated.

It is this tonnage, plus the war needs for other products normally consuming zinc, which is making it difficult for civilian users to obtain all of the zinc they would like to use.

THE NEW JERSEY ZINC COMPANY

MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS

4 BRASS

CERAMICS

DIE CASTING

METAL SPRAYING

GALVAN-IZING

PHARMA-CEUTICALS

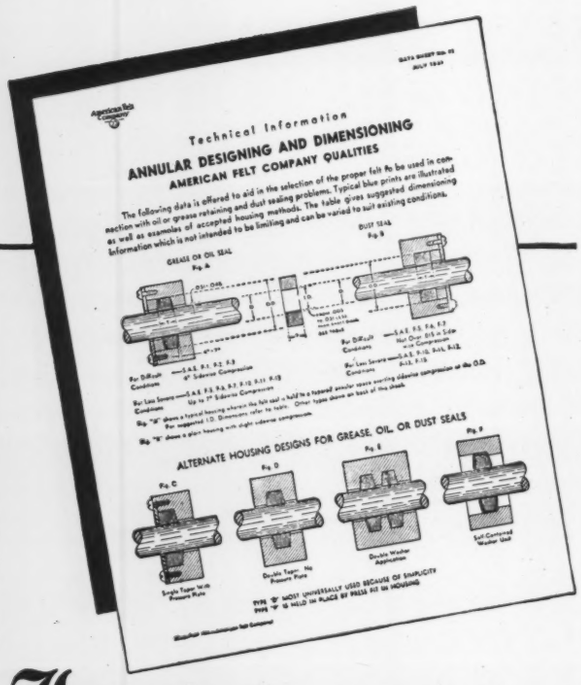
NICKEL SILVER

1 HULL PLATES

2 RUBBER

3 PAINT

New Jersey Zinc


Technical Information

ANNULAR DESIGNING AND DIMENSIONING
AMERICAN FELT COMPANY QUALITIES

The following data is offered to aid in the selection of the proper felt to be used in connection with oil or grease retaining and dust sealing problems. Typical blue prints are illustrated as well as examples of accepted housing methods. The table gives suggested dimensioning information which is not intended to be limiting and can be varied to suit existing conditions.

GREASE OR OIL SEAL
Fig. A

DUST SEAL
Fig. B

ALTERNATE HOUSING DESIGNS FOR GREASE, OIL, OR DUST SEALS

Fig. C — Single Taper With Pressure Plate

Fig. D — Double Taper, No Pressure Plate

Fig. E — Double Washer Application

Fig. F — Self-Centered Washer Seal

Insurance

through the use of a

BETTER FELT RING

can easily cost much less than the price of a sub-grade washer

Of the many industrial uses of felt, none are more vital than oil and grease retention and dust exclusion. Nothing but felt will hold oil as a reservoir ready to bleed the lubricant to the friction point. Only felt ... and no other material ... meets the rigid requirements that insure long and successful ball bearing life. Even under conditions of misalignment, felt washers adapt themselves readily because of the inherent resiliency of felt. Felt insures a close, snug fit, and felt washers perform the dual function of retaining the lubricant and of excluding foreign matter. In special applications felt may be impregnated or chemically treated.

Data Sheet 11, "Annular Designing and Dimensioning," just issued will aid you in the selection of *proper* felt, and assist you in setting up your blue-prints. Please write for it.

American Felt Company

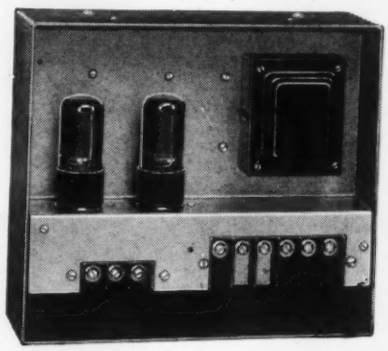
TRADE MARK

General Offices: GLENVILLE, CONN.

Sales Offices at
New York—Boston—Chicago—Philadelphia—Cleveland—Detroit—St. Louis—San Francisco

PRODUCERS OF FINEST QUALITY PARTS FOR OIL RETAINERS, GREASE RETAINERS, WICKS, DUST EXCLUDERS, GASKETS, INSULATING FELTS, CHANNEL FELTS, UPHOLSTERY RISER STRIPS, BODY SILENCING PARTS, DOOR MECHANISM GASKETS, AND BODY POLISHING WHEELS

contact, with an antenna or metal rod electrode, mounted on insulated supports in container, volume of flow of electrons in tube is changed. This variation in electronic flow activates a magnetic relay to open or close an electric load circuit. Electrode has no chemical reaction on contents. Each



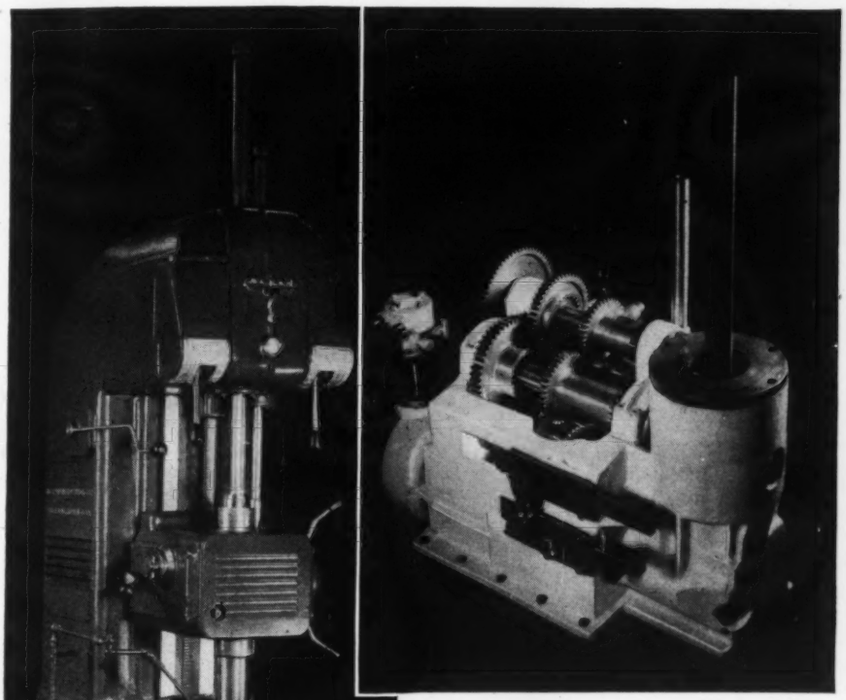
switch is fitted as standard, with an auxiliary emergency tube circuit which automatically gives a signal and carries on the operation should the regular electronic circuit fail for any reason. This control may be installed at any distance from the container, up to 500 feet.

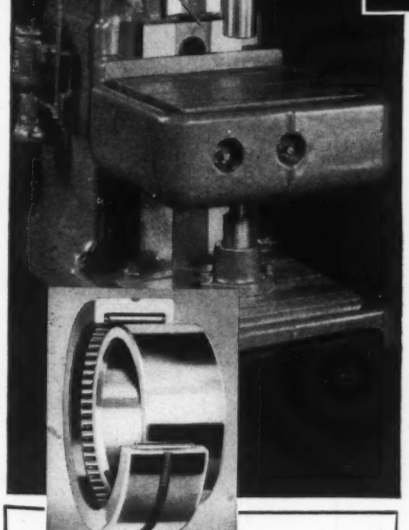
Two-Speed Fan Control

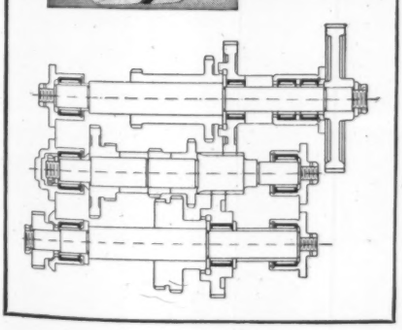
FOR forced warm-air systems employing two-speed fans, a fan control has been announced by Perfex Corp., 500 West Oklahoma avenue, Milwaukee. The greater range of air delivery obtainable with two-speed fans produces minimum variation

in temperature of air delivered as well as faster heating. When the temperature rises, the switching system is designed to start the fan in low speed, in order to protect the fan motor. Control can be set to switch fan from low to high speed at any

IN THE NEWS
WITH BANTAM BEARINGS

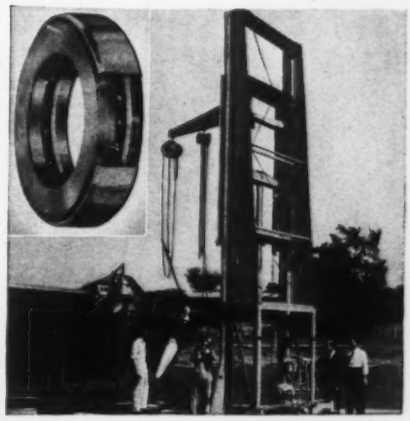




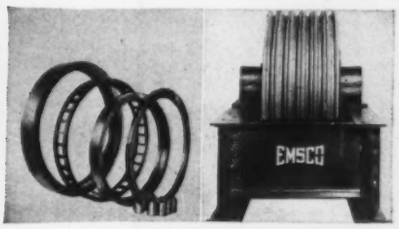


THE TOUGHEST JOBS for emergency wartime as well as peacetime needs can be handled by this new 25" geared drilling machine, manufactured by Sibley Machine & Foundry Corp. It is designed to combine tremendous power with high speed, efficient operation, and long life. The use of Bantam Quill Bearings helps to achieve this exacting performance. This is an excellent illustration of one of the ways these bearings are used in machine tools.

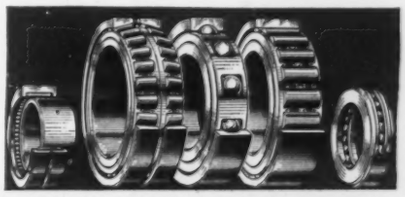
IN THE TRANSMISSION, fifteen Quill Bearings are used: nine on the speed side, six on the feed side. Their ability to carry heavy loads in a small space made possible the use of anti-friction bearings throughout the compact design, shown in the accompanying cross-section. Notice particularly how the use of Quill Bearings has aided in simplification of the housing design and other surrounding members. Completely self-contained, Bantam Quill Bearings are easily installed, admirably adapted for production line methods. And low initial cost helps to keep production costs down. For complete details on this unusual bearing, write for Bulletin B-104.



ONE OF THE LARGEST hydraulic portable elevators ever built, constructed by the LYON-Raymond Corporation, is designed for use in the installation and removal of airplane engines—including those on the largest bombers. It has a capacity of 5,000 pounds and an elevation speed of approximately 12 feet per minute To assure efficient performance and ready maneuverability of elevator and load, Bantam Ball Thrust Bearings are used in the auto-type steering mechanism.



THE THRUST SHOULDER BUILT INTO THE OUTER RACE of this Bantam Journal Roller Bearing eliminates hazardous thrust washers and allows for compactness—a typical instance of Bantam's cooperation in equipment design. Bearings of this type are used in each of the sheaves in crown and traveling blocks built by Emsco Derrick & Equipment Co. Bantam's Journal Roller Bearings find many other uses in oil-field equipment for such applications as swivels, drawworks, slush pumps, reverse clutches, and pumping units.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARING is included in Bantam's line—straight roller, tapered roller, needle, and ball. Bantam engineers, with their broad background of experience in bearing design and application, can recommend the type that best suits your needs—and design special bearings to meet special conditions. If you have a difficult bearing problem, TURN TO BANTAM.

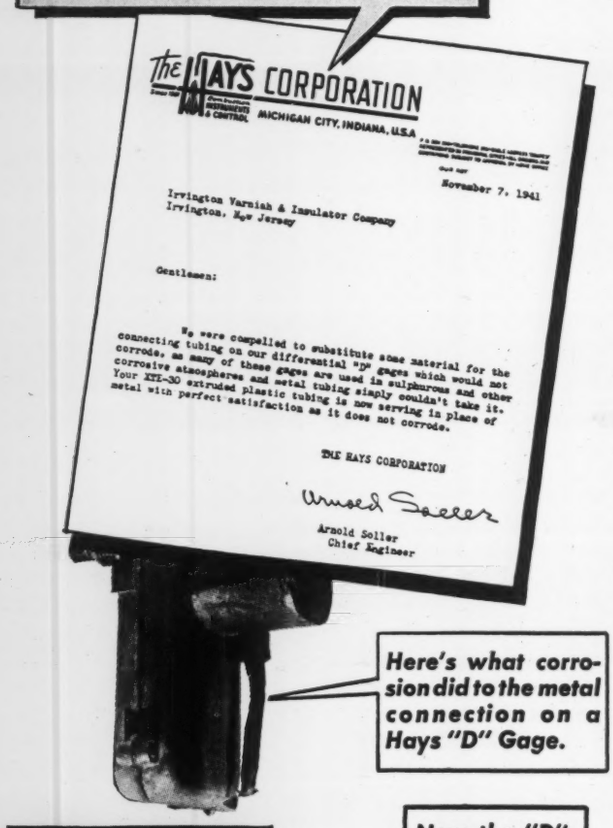
BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

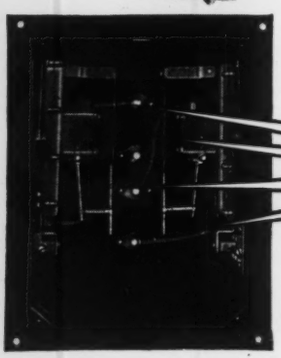
BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

USES CORROSION PROOF IRV-O-LITE PLASTIC TUBING ON THEIR "D" GAGES

The sharp teeth of corrosion were biting into metal connecting tubing on Hays Differential "D" Gages. Read how this problem was perfectly solved with IRV-O-LITE XTE-30 extruded plastic tubing.


The HAYS CORPORATION
MICHIGAN CITY, INDIANA, U.S.A.
November 7, 1941
Irvington Varnish & Insulator Company
Irvington, New Jersey
Gentlemen:
We were compelled to substitute some material for the connecting tubing on our differential "D" gages which would not corrode, as many of these gages are used in sulphurous and other corrosive atmospheres and metal tubing simply couldn't take it. Your XTE-30 extruded plastic tubing is now serving in place of metal with perfect satisfaction as it does not corrode.
THE HAYS CORPORATION
Arnold Soller
Chief Engineer

Here's what corrosion did to the metal connection on a Hays "D" Gage.



Now the "D" Gages connections are fully protected against corrosion by IRV-O-LITE XTE-30.

In addition to eliminating corrosion, your metal shortage problems can be met by using IRV-O-LITE XTE-30 plastic tubing as a substitute material. Try XTE-30 for replacement, it will give equally fine results and performance—may do an even better job as in the case of The Hays Corporation.

Also for electrical insulation, IRV-O-LITE XTE-30 extruded plastic tubing has high dielectric and mechanical strength, exceptional resistance to tearing, abrasion, heat, fire and solvents. Its extreme flexibility and smooth inside surfaces enables quick assembly on wires.

Test IRV-O-LITE XTE-30 yourself.
We'll send you samples. Write Dept. 86.

Irvington VARNISH & INSULATOR CO.

IRVINGTON, NEW JERSEY, U. S. A.

PLANTS AT IRVINGTON, N. J. HAMILTON, ONT., CAN.

Representatives in 20 Principal Cities

desired bonnet temperature. All cut-in and cut-out settings are made independently. Bonnet temperature is indicated on an external scale. Continuous high-speed fan operation without disturbing temperature setting can be produced by turning an external knob to "summer cooling."

High Temperature Lubricant

GRAPHITED oil for lubricating chains, sprockets, bearings, rollers, etc., in bakers ovens is being marketed by Norwood Products Co., 75 East Wacker drive, Chicago. Being odorless, the new Kano Ovenoil will not contaminate food products. Having high penetrating properties, it creeps into all bearing surfaces where it builds up graphoid surfaces which provide proper lubrication at high temperatures. Absence of gum and carbon residue in oil avoids clogging of bearings, flaking in the oven, etc. Use of colloidal graphite results in a stable fluid.

Vulcanized Fiber Insulation

ANNOUNCED by N. S. Baer Co., 13 Evans Place, Hillside, N. J., is a new insulation, vulcanized fiber surfaces on a laminated phenolic material. This insulation is especially suited where there is an arcing condition, as the vulcanized fiber quenches the arc without carbonizing or tracking and the phenol fiber gives necessary rigidity and moisture-resistant qualities. Material can be punched, sawed, drilled or tapped.

Conduit Clamps with Speed Nuts

CONDUIT clamps with speed nuts attached have been announced by Tinnerman Products Inc., 2085 Fulton road, Cleveland. Clamps are the standard type AC-755 except that speed nuts are attached to either the upper or lower leg of the clamp for faster assembly. Speed nut is designed with extrusions on lower legs of nut that snap into a hole in the clamp to hold the speed nut in position. The new clamp with speed nut enables the assembler to handle only the clamps, a screw, and screw driver, thus saving considerable time. The speed nut weighs less than half as much as

the standard lock-nut formerly used. Made of molybdenum spring steel the new nut fastens the assembly with a double spring-lock that overcomes loosening due to vibration.

Ask Anyone in Industry!

Photograph shows installation on head end gearing of Whitin spinning frame.

ALEMITE PROGRESSIVE SYSTEM LUBRICATES ALL BEARINGS DEPENDABLY WITHOUT INTERRUPTING PRODUCTION! PROMOTES SAFETY! CUTS COSTS!

SAYS NORTH CAROLINA MILL

Delivers Predetermined Quantity of Grease to Each Bearing—Signals When Finished

WITH all America on a war basis, uninterrupted production becomes more important than ever. This North Carolina mill (name on request) has found that the Alemite Progressive Lubrication System helps to speed production by permitting centralized lubrication of bearings *while machines are in operation!*

This new centralized system saves machine-hours and man-hours. It delivers a predetermined amount of grease to each bearing, and signals when lubrication is completed. It promotes safety by bringing remote bearings into easy reach.

Write today for complete details! Let us show you how easily, quickly, and inexpensively this system can be installed—and how it pays for itself in a short time! No obligation!

ALEMITE

REG. U. S. PAT. OFF.

Industrial LUBRICATION

1804 DIVERSEY PARKWAY, CHICAGO, ILLINOIS • BELLEVILLE, ONTARIO

Another Product of STEWART WARNER

Arkwright Standards STAND!

As industry rushes to its battle stations, it can be sure that its designers and draftsmen will continue to have good quality tracing cloth to work with.

For Arkwright standards stand . . in war as well as peace!

In 1939 Arkwright standards – smooth, smudge-proof surface and permanently transparent finish – meant a good deal to draftsmen working on consumer goods production. But think how much more essential they are in 1942 as industry speeds up its war supplies output.

Besides maintaining the quality of its tracing cloths, Arkwright also maintains sufficient stock to assure dependable delivery to defense and non-defense industries. Write for samples and new catalog. Arkwright Finishing Company, Providence, Rhode Island.

Arkwright

TRACING CLOTHS

"AMERICA'S OLDEST AND FINEST"

Sold by Leading Drawing Material Dealers Everywhere

Gov't Field Offices for Contract Distribution

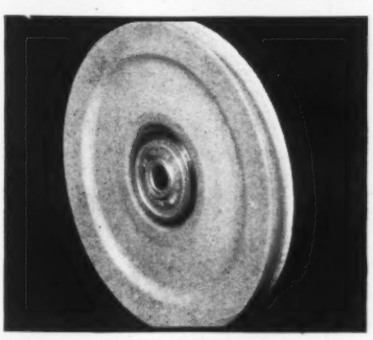
Field offices established by the former OPM Division of Contract Distribution (most of which are likely to be retained), and also their principal personnel, are listed below. These offices provide information and engineering assistance to prospective producers of war materiel. Manufacturers seeking war work should take or send to the nearest field office full information regarding their equipment and the products they normally manufacture.

State	Manager		Address
Alabama			
*Birmingham	L. E. Geohegan	E. Lee Norton	301 Phoenix Bldg.
Arizona			
*Phoenix	Fred F. Schalmo (acting)		406 Security Bldg.
Arkansas			
*Little Rock	Alfred M. Lund (state director)	Charles L. Tompson (chairman, advisory comm.)	304 Recor Bldg.
California			
*Fresno	E. H. Cameron (acting)		Mattei Bldg.
Los Angeles	Howard Hutchins	W. S. Rosecrans	1031 S. Broadway
Oakland	W. P. Collins (acting)		Financial Center Bldg.
San Diego	Paul C. Farmer (acting)		510 Union Bldg.
San Francisco	Col. Francis M. Smith		Furniture Mart
Colorado			
*Denver	Clyde C. Hartzell (state director)	Wm. L. Petrikin (chairman, advisory comm.)	U. S. National Bank Bldg.
Connecticut			
*Hartford	Carl Gray (state director)		Phoenix Bank Bldg.
Bridgeport	Raymond L. French (acting)		Professional Bldg.
Delaware			
Wilmington	Bradley L. Giest (acting)		314 Penn Bldg.
Florida			
*Jacksonville	Chas. C. McCubbin (state director)	George W. Simons (chairman, advisory comm.)	620 Hildebrandt Bldg.
Miami	Forrest D. Banning (acting)		514 Congress Bldg.
Tampa	Arthur B. Hale		901 Wallace South Bldg.
Georgia			
*Atlanta	W. C. Cram Jr.	Wiley Moore (chairman, advisory comm.)	Suite 150. Hurt Bldg.
Idaho			
*Boise	H. W. Bogie (acting)		409 Capital Securities Bldg.
Illinois			
*Chicago	Thos. S. McEwan		Federal Reserve Bank Bldg.
Springfield	Edward Gerrity		407 Leland Office Bldg.
Indiana			
*Indianapolis	Frank Hoke (state director)		Circle Tower Bldg.
Evansville	J. T. Mooney (acting)		Koenig Bldg., Rm. 8
Iowa			
*Des Moines	George Beese (state director)	Vernon L. Clark (chairman, advisory comm.)	505 Crocker Bldg.
Kansas			
*Wichita	Harold Hartzell (state director)	George B. Weeks (chairman, advisory comm.)	517-518 Union National Bank Bldg.
Kentucky			
*Louisville	Prentiss M. Terry		200 Todd Bldg.

*Main office in state.

Engineered Specialties IN LAMINATED PLASTICS

Colorful, chemically inert, spot-proof and cigarette-proof table tops developed by Formica and now widely used in restaurants and public rooms everywhere — including industrial restaurants.



Formica control pulleys now produced by the hundreds of thousands and used on all leading American makes of airplanes.

FORMICA has always aimed at building a large percentage of its business on special products for the development of which much research and engineering work has been necessary. For that purpose it has a large and competent engineering force which has been successful in producing many new products—products for which laminated phenolic material had not been previously used.

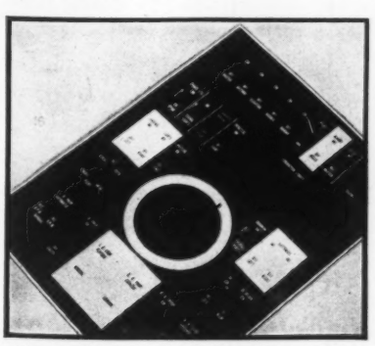
We illustrate a few of them here: table tops, airplane pulleys, instrument panels with fluorescent markings, grounded static-proof truck-tires, slitting discs for rayon manufacture. These are representative of several hundred similar items.

Formica is always searching for more opportunities to develop new products that fall within the limits of the material with which it works. The Formica engineering department will be glad to cooperate if you have a need for something that might be developed and will gladly give you an opinion as to applicability of the material for your purposes.

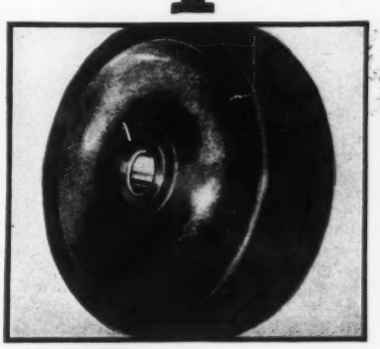
The Formica Insulation Company

4648 Spring Grove Avenue, Cincinnati, Ohio

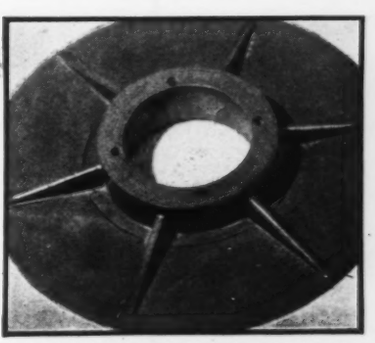
FORMICA



Instrument panels with fluorescent markings which are brilliantly legible in the dark interior of a fighting airplane's cabin when illuminated by black light.



A Formica truck tire which will not strike sparks mechanically and is so grounded that a static potential may not be built up which would cause a spark. Used where explosives of any kind are handled.



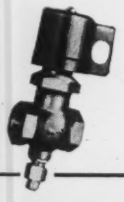
A slitting disc used in rayon manufacture and developed to emphasize resistance to alkalis. Formica parts of rayon equipment last months where material formerly used lasted weeks.

THERE IS NOW A *Better*

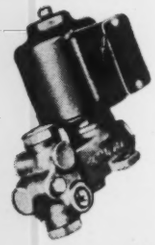
SOLENOID VALVE

FOR EVERY SERVICE...

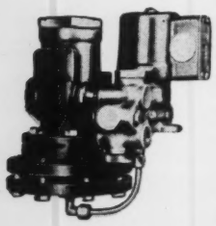
Standard or Special!



Here is a line of solenoid valves that is complete—not only in the wide range of stock types for standard services, but in a full complement of tailor-made types for special services.

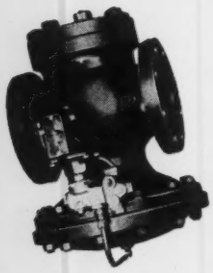


And—whether standard or special, each Asco Valve contains *every* refinement of design and construction requisite to low-cost, trouble-free operation throughout *years* of service.



If you have a perplexing problem involving the automatic or remote control of air, steam, liquids or gas, there's one way of getting the right answer—*the first time.* Simply tell us what you wish to accomplish.

Our engineers will study your problem and submit our recommendations—not on a "misfit" or a "makeshift," but on a valve that will meet your *every* requirement, effectively and economically.



AND IF YOU USE AUTOMATIC SWITCHES...

... investigate the complete line of Asco Electrically-Operated Switches including automatic transfer switches, remote control switches, contactors and relays as well as special switches for special services.

THESE NEW CATALOGS MAY HELP YOU TO SOLVE YOUR ELECTRIC CONTROL PROBLEMS

Catalog 549 . . . . an eighty-page catalog on automatic transfer switches, remote control switches, contactors and relays — covers what they are, why they are used, their features, capacities, construction, and operation.

Catalog 149 . . . . a seventy-page catalog on shut-off and trip valves, three-way and four-way pilot valves for steam, air, liquids, and gases—a manual on sizes, types, capacities, pressure ranges, adjustment, operation, and maintenance.

Automatic Switch Co.

49 EAST 11th STREET, NEW YORK, N. Y. 2-AS-2

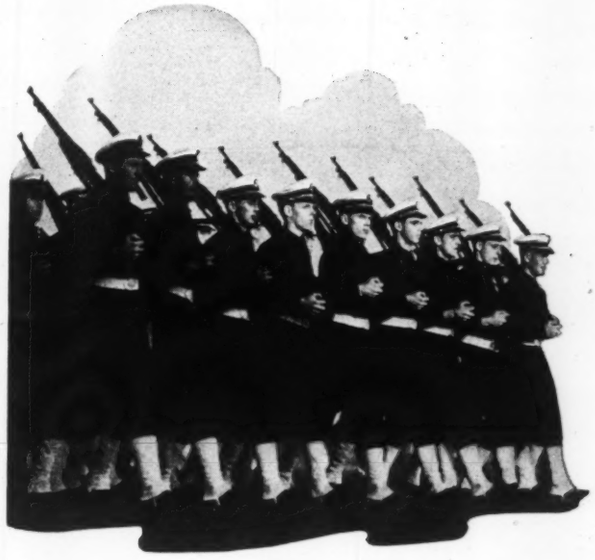
TELL US WHAT YOU WISH TO ACCOMPLISH

State	Manager		Address
Louisiana			
*New Orleans	R. E. Judd (state director)	A. B. Paterson (chairman, advisory comm.)	Rm. 423 Canal Bldg.
Shreveport	R. H. Cone (acting)		916 Giddens Lane Bldg.
Maine			
Bangor	Charles E. Walker (acting)		363 Union St.
*Portland	Herbert Payson Jr. (state director)		Rm. 501-502, 443 Congress St.
Maryland			
*Baltimore	G. W. Creighton (state director)	W. F. Roberts (chairman, advisory comm.)	Federal Reserve Bank Bldg.
Massachusetts			
*Boston	Edward V. Hickey (state director)		17 Court St.
Fall River	Harold S. Ramsay (acting)		27 South Main St.
Lowell	W. E. Standwood (acting)		Sun Bldg., 8 Merrimac St.
Springfield	Howard G. Philbrook		95 State St.
Worcester	Dwight Clark Daniels		State Mutual Bldg.
Michigan			
*Detroit	Warren H. Clarke (state director)	Clarence Avery (chairman, advisory comm.)	Federal Reserve Bank Bldg.
Minnesota			
*Minneapolis	Harold C. Timberlake	Roger Shepard (chairman, advisory comm.)	Midland Bldg.
Mississippi			
*Jackson	A. G. McIntosh (acting)		610 Tower Bldg.
Missouri			
*St. Louis	F. J. McDevitt		Federal Reserve Bank Bldg.
Kansas City	R. W. Webb		Federal Reserve Bank Bldg.
Montana			
*Helena	R. E. Towle (state director)	J. E. O'Connell (chairman, advisory comm.)	Federal Reserve Bank Bldg.
Nebraska			
*Omaha	Arthur Walker (state director)		501 Grain Exchange Bldg.
Nevada			
*Reno	Leonard E. Faber (acting)		Saviers Bldg.
New Hampshire			
*Manchester	S. H. Dann (acting)		Amoskeag Industries Bldg.
New Jersey			
*Newark	R. L. Kennedy (state director)	Tom Jones (chairman, advisory comm.)	176 Sussex Ave.
New Mexico			
*Albuquerque	George Lusk (acting)		103½ W. Central Ave.
New York			
*New York City	W. O. Crabtree		Chanin Bldg.
Albany	F. J. Holman		State Bank Bldg.
Brooklyn	Emile Weinberg		16 Court St.
Buffalo	Thos. J. O'Rourke	John J. Lenahan	Manufacturers' & Traders' Bank Bldg.
Rochester	Mahlon Gregg		119 East Main St., Commerce Bldg.
Syracuse	T. D. Harter		302 Starrett-Syracuse Bldg.
North Carolina			
*Charlotte		Frank H. Cothran (chairman, advisory comm.)	New Liberty Life Bldg.
North Dakota			
*Bismarck	Paul W. Fawcet (acting)		14 First Nat'l Bank Bldg.
Ohio			
*Cleveland	Dr. Charles Terry (state director)	Herman Lind (chairman, advisory comm.)	Union Commerce Bldg.
Cincinnati	Clifford Schulte	Clifford Wright	Room 804, Union Trust Bldg.
Columbus	Benjamin J. Zuhars (acting)		305 Spahr Bldg.
Dayton	Collins Wright (acting)		1021 Third Nat'l Bank Bldg.
Toledo	Henry A. Jordon (acting)		519 Spitzer Bldg.
Youngstown	Leif Oyen (acting)		1002 Union Nat'l. Bank Bldg.

*Main office in state.

(*Concluded on Page* 120)

KEEP MACHINE PRODUCTION MARCHING, TOO!



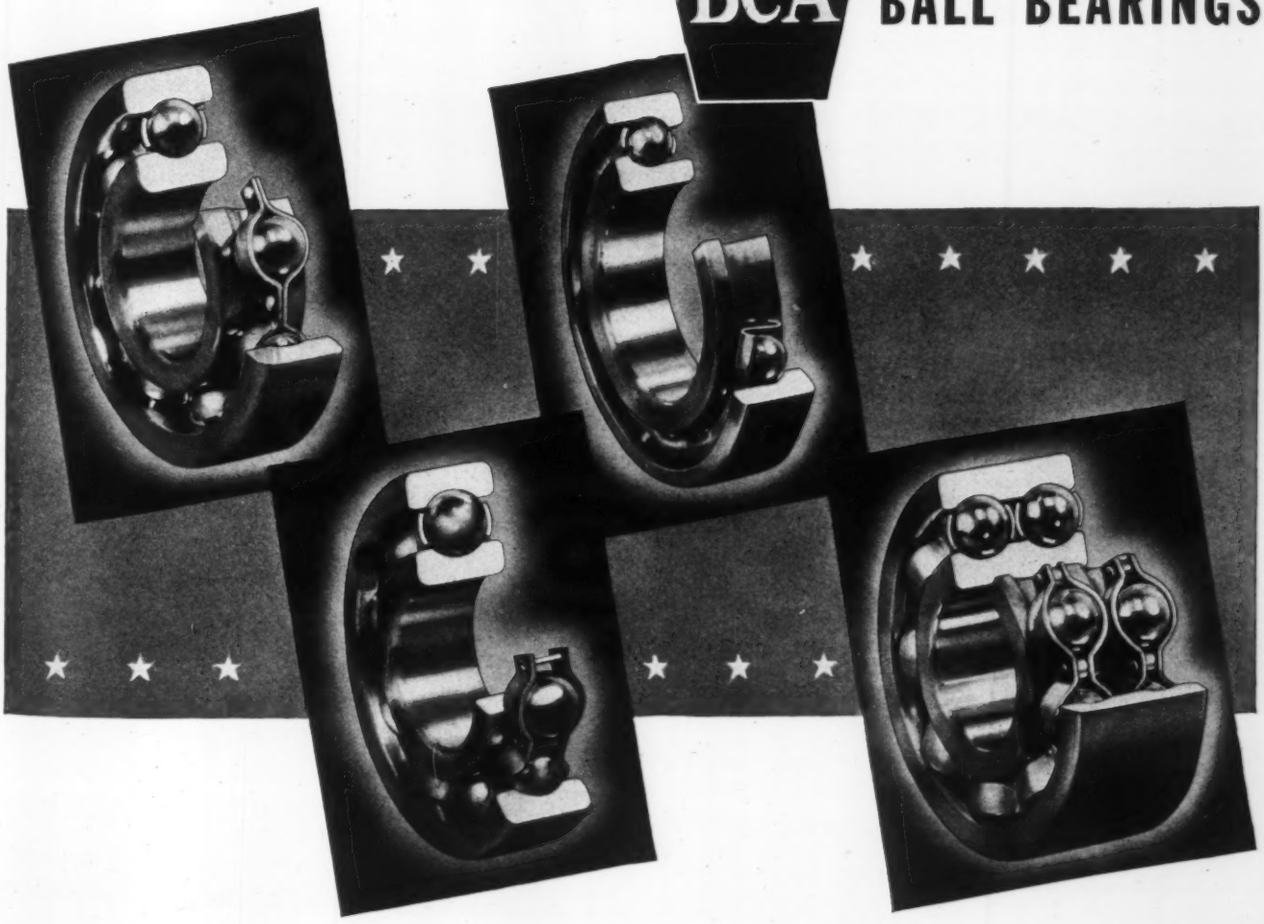
AMERICA'S march to victory will be the march of machine production. Guard against the risk of shutdowns! Specify BCA Ball Bearings. Rugged in construction . . . accurate in design . . . trouble-free in performance . . . these ball bearings protect critical contact points against friction and stresses. Machine users' production . . . machine manufacturers' reputations . . . both benefit from the use of BCA Ball Bearings.

BEARINGS COMPANY OF AMERICA, LANCASTER, PA.

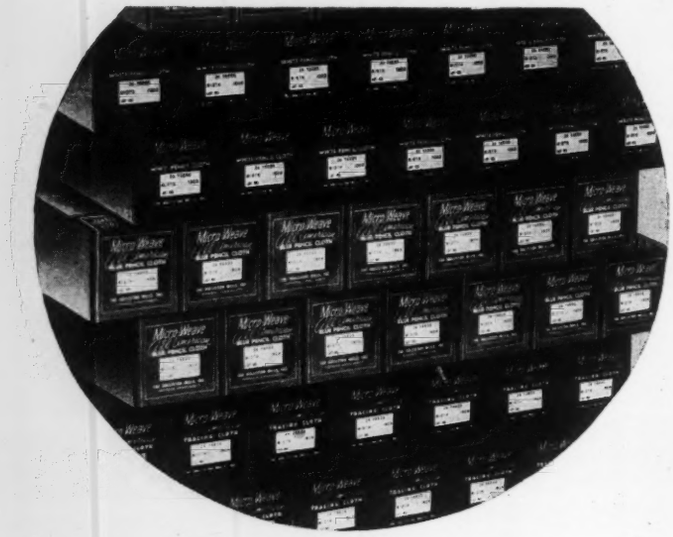
BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS



The Foundation of a Reputation



THOSE boxes—thousands and tens of thousands of them filled with tracing cloth and emptied foot by foot and yard by yard onto the drafting room tables, meeting the test of actual use—form the foundation of Micro-Weave reputation. Not claims, not theory, but actual performance has established a factual record. It means something when a product, in the experimental laboratory stage a little more than four years ago, can go into a competitive market and on its merits establish itself beyond question or argument. Micro-Weave has a reputation earned the hard way—it has thousands of users who specify and buy it—because they were willing to try it and, having tried it, found it good.

Ask your dealer or write us for free test samples.

The Holliston Mills, Inc., Norwood, Mass.

BOSTON NEW YORK PHILADELPHIA
CHICAGO ST. LOUIS RICHMOND

(*Concluded from Page 114*)

State	Manager		Address
Oklahoma			
*Oklahoma City	Morton R. Harrison (state director)	Fred Jones (chairman, advisory comm.)	540 Key Bldg.
Oregon			
*Portland	John G. Barnett (acting)	Thomas Harry Banfield	815 Bedell Bldg.
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Allentown	Ernest R. Follin Jr. (acting)		506 Hamilton St.
Chester	Abbott Smith		12-14 E. Fifth St.
Erie	Harry B. Joyce (acting)		Erie Trust Co. Bldg.
Harrisburg	Ritchie Lawrie Jr. (acting)		Black Stone Bldg.
Johnstown	John S. Wagoner		U. S. Nat'l Bank Bldg.
Lancaster	Arthur K. Barnes		655 Woolworth Bldg.
Norristown	Geo. Peterson Jr.		306-308 Norristown-Penn Trust Bldg.
Pittsburgh	M. F. McOmber	Alex E. Walker	406 Fulton Bldg.
Reading	John A. Archer (acting)		615 Penn St.
Scranton	Alfred T. Snyder (acting)		Rm. 717 First National Bank Bldg.
Wilkes-Barre	W. H. Pierce		53 W. Market St.
Williamsport	H. D. Stuempfle		Susquehanna Trust Co. Bldg.
York	Richard S. Cole		Manufacturer's Assn. Bldg.
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*Providence	Walker Mason (state director)	Col. William Shawcross (chairman, advisory comm.)	530 Industrial Trust Bldg.
S. Carolina			
*Columbia	Harry G. Greene (acting)		Rm. 204-206 Manson Bldg.
South Dakota			
Sioux Falls	Fred M. Chase (acting)		309-310 Boyce Greely Bldg.
Tennessee			
*Memphis	Arthur M. Field (state director)	Arthur J. Dyer (chairman, advisory comm.)	2112 Sterrick Bldg.
Chattanooga	Paul E. Shacklett		909-910 James Bldg.
Knoxville	W. W. Mynatt (acting)		202-204 Goode Bldg.
Nashville	W. G. Whitsitt		1014 Stahlman Bldg.
Texas			
*Dallas	A. J. Langford	Chas. R. Moore	Fidelity Bldg.
El Paso	L. A. Wilke	W. R. Blair	222 El Paso National Bldg.
Houston	I. M. Griffin	R. Lee Blaffer	Federal Reserve Bank Bldg.
San Antonio	P. E. Locke	Hull Youngblood	1100 South Texas Bank Bldg.
Utah			
*Salt Lake City	Bayard W. Mendenhall (acting)	Geo. M. Gadsby	432 Utah Oil Bldg.
Vermont			
*Montpelier	A. M. Creighton Jr. (acting)		12 State St.
Virginia			
*Richmond	Julian Lorin Mason		Johnson Publishing Bldg., Fifth & Cary Sts.
Washington			
*Seattle	F. C. Bold	J. G. Larson (chairman, advisory comm.)	National Bank of Commerce Bldg.
Spokane	T. Wilber Weger		Rm. 629-630 Old National Bank Bldg.
West Virginia			
Wheeling	M. S. Sloman (acting)		1025 Main St., Hawley Bldg.
Wisconsin			
*Milwaukee	Clifford E. Ives (state director)	Harold H. Seaman (chairman, advisory comm.)	610 First Wisconsin National Bank Bldg.
Eau Claire	Dorance W. Walters (acting)		128½ Graham Ave.
Wyoming			
*Casper	H. C. Gustafson (acting)		P. and R. Bldg.

*Main office in state.

Efficient VIBRATION CONTROL

Depends On Two Factors Found In All LORD SHEAR TYPE MOUNTINGS

LORD
BONDED RUBBER

① AXIAL SOFTNESS

It is an engineering principle that for a known load and disturbing frequency, the degree of vibration isolation in any elastically mounted system increases as the deflection of the mountings increases. Adequate deflection of the mountings under load is essential, therefore, in reducing the natural frequency of the mounted assembly.

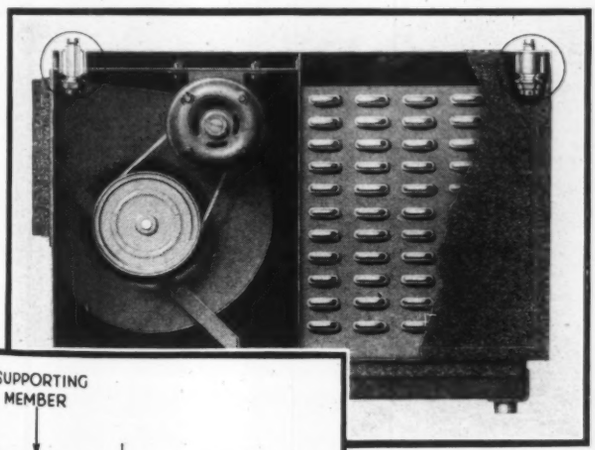
② RADIAL STABILITY

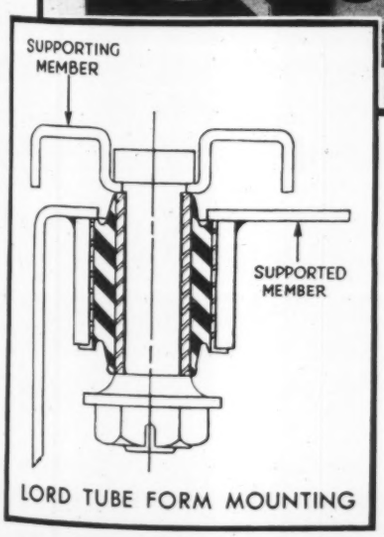
From the practical viewpoint, one other mounting characteristic is desirable in efficient vibration control; namely—the mountings should be soft *only* in the direction of the vibratory forces. Mountings that are soft in all directions are unstable, and will usually produce excessive and uncontrollable movements of the mounted assembly.

LORD engineers have perfected bonded rubber-to-metal mountings that embody the two essential factors for efficient vibration control discussed at the left. These compact, easy-to-install mountings operate on the principle of creating shear stress in the rubber when under load. Experience has proved that for practical applications, rubber stressed in shear is softer and more stable under load than when stressed in either tension or compression. In Lord Shear Type Mountings, therefore, adequate deflections are obtained without resorting to large masses of rubber that would result in an unstable assembly.

Lord Mountings are made in Plate Form, for supporting loads from a few ounces up to 300 pounds each, and in Tube Form, for loads up to 1500 pounds each.

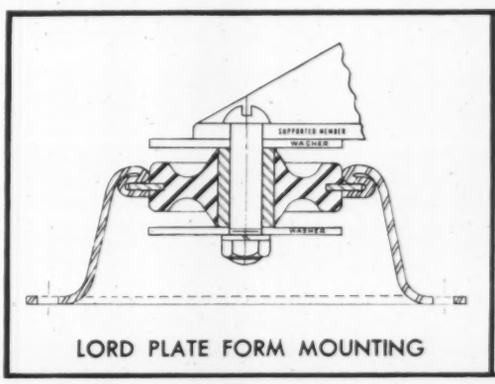
In a radio installation similar to the one shown below, based on a disturbing frequency of 1750 c.p.m., a 3/32" deflection of the mountings, and a load per mounting point of 19½ lbs., 88% of the vibration in the supporting structure would be prevented from reaching the radio. In the Waukesha truck type evaporator shown at the left, the Lord Tube Form Mountings perform the dual function of isolating the truck body from vibrations generated in the unit, and likewise protect the blower assembly from road shock. Lord Bulletin No. 104, describes the use of Lord Mountings on many different types of equipment and contains valuable engineering data on vibration control. Write for your copy.



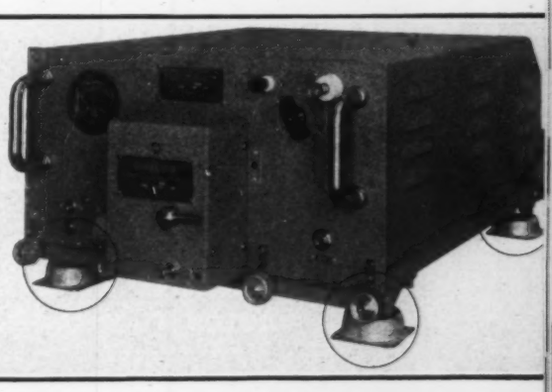


LORD TUBE FORM MOUNTING

Lord Mountings are made in a variety of standard styles and types to fit practically any mechanical installation.



LORD PLATE FORM MOUNTING



LORD MANUFACTURING COMPANY . . . ERIE, PA.

245 E. OLIVE AVE., BURBANK, CAL. 280 MADISON AVE., NEW YORK 844 N. RUSH ST., CHICAGO

IT TAKES RUBBER IN SHEAR TO ABSORB VIBRATION

ON THE COUNTRY'S
ACTIVE SERVICE
HONOR ROLL

HANSEN *Push-Tite*
AIR HOSE COUPLINGS

SPEED, EFFICIENCY and ECONOMY is the order of the day in all industrial and aviation plants handling Army, Navy and Aviation jobs. Hansen Push-Tite air hose couplings have been called for active duty in hundreds of these plants because they are the most dependable, efficient and easiest to operate air hose coupling on the market. To connect a Hansen Push-Tite air hose coupling merely give the plug a slight push into socket, it is connected and the air is automatically turned on. An easy pull back on sleeve and it is disconnected instantly and air is automatically shut off.

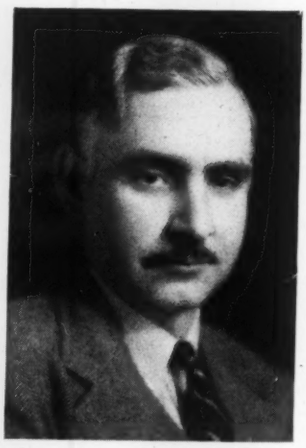
Hansen Push-Tite air hose couplings are absolutely air tight at all pressures, no leakage at any time. There is no twisting or turning of parts in order to connect or disconnect and no kinking or twisting of hose due to complete swivel action of coupling.

Write for free catalog

Hansen MFG. CO.
INDUSTRIAL AIR LINE EQUIPMENT
1786 E. 27TH STREET • CLEVELAND, OHIO

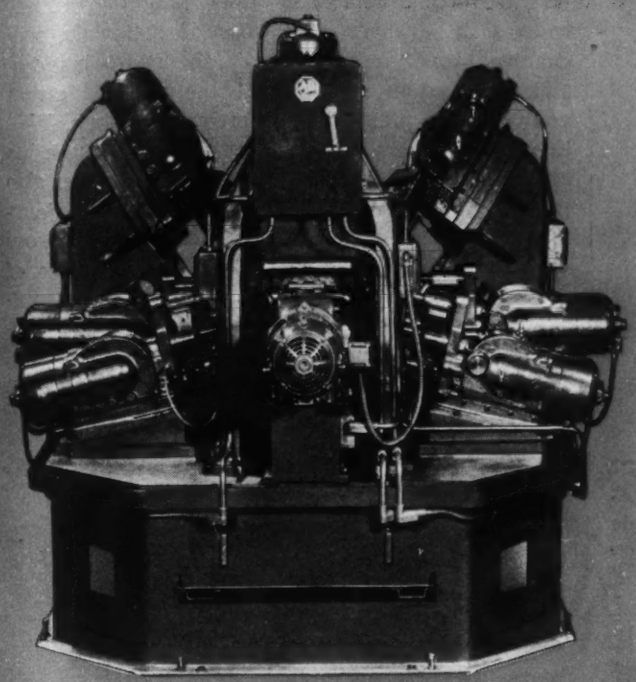
MEN *Of Machines*

PROMOTION of Harry D. Bubb of Thompson Products Inc., Cleveland, from chief engineer of the Cleveland plant to director of engineering for both the Cleveland plant and the Thompson Aircraft Products Co., a subsidiary, in Euclid, O., has been announced recently. After graduating from Case School of Applied Science in 1925 he worked in the metallurgical laboratory of Thompson Products. Four years later he became chief metallurgist and in 1934 chief engineer. He is a member of the Society of Automotive Engineers, American Institute of Mining and Metallurgical Engineers and the Institute of Metals, England.



UNTIL recently connected with the Illinois Institute of Technology as associate professor, Joseph Marin has been made professor of engineering mechanics at Pennsylvania State College. His new position involves teaching of engineering mechanics courses and research work on mechanical properties of materials and analytical problems in stress analysis. He received his Ph.D. in engineering mechanics in 1936 at the

Welded STEEL Machine BASES



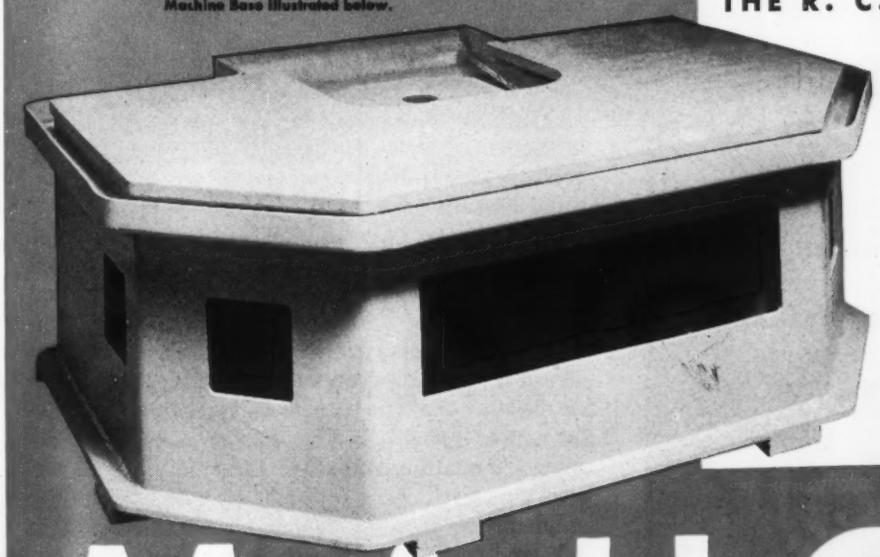
Above: Multiple Spindle, Way Type Drilling Machine for the simultaneous multiple drilling of airplane engine cylinder heads, produced by Kingsbury Machine Tool Corporation, Keene, N. H., assembled to Mahon Welded Steel Machine Base illustrated below.

Builders of Precision Machines KNOW the VALUE of Mahon *Precision-Built* Bases

Producing a precision multiple drilling machine, such as pictured on this page, requires not only exceptional skill and knowledge but a heavy expenditure of time and money. It is sound economy, therefore, to make sure that the base upon which it is mounted is built with equal precision. The Kingsbury Machine Tool Corporation, Keene, N. H., who builds this machine, relies on Mahon experience and exacting fabrication methods to insure accuracy of fit and finer finished appearance—and to save subsequent costly machining. Depending on Mahon for Machine Base requirements likewise has become a thrifty habit with hundreds of other foremost machine tool manufacturers. Send us YOUR blueprints for quotations. They will be given prompt attention.

THE R. C. MAHON COMPANY
DETROIT, MICHIGAN

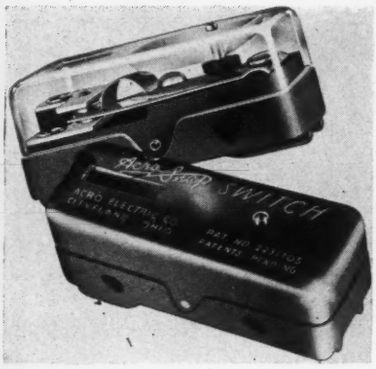
Manufacturers of Machine Bases and Many Other Steel Products



This reproduction from an unretouched photograph clearly shows the clean-cut, smooth appearance and accuracy of workmanship of Mahon precision-built Welded Machine Bases.

MAHON

SLIGHT BLADE FLEXURE MEANS *Long Life* TO *Acro Snap* SWITCH

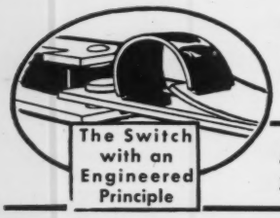


The unique design of the ACROSNAP SWITCH with its rolling spring to snap the blade from one position to the other permits actuation with a very slight flexure of the blade.

Since metal fatigue is governed by the relation of the unit stress to the elastic limit of the material it follows that this minimum flexure means exceptional long life for ACROSNAP SWITCHES.

Available with all ordinary types of actuation—leaf, spring plunger, etc.

Write for complete information advising purposes for which switches are required.



ACRO ELECTRIC CO.
3179 Fulton Rd., Cleveland, Ohio

WILLIAMS
"SUPERIOR"
DROP-FORGINGS
Any Shape
Any Material
Complete Facilities

FREE . . . .
Forging Data Folder—Helpful, Informative. Write Today.

J. H. WILLIAMS & CO.
"The Drop-Forging People"
400 Vulcan St.
BUFFALO, NEW YORK

"Forge ahead with Forgings"

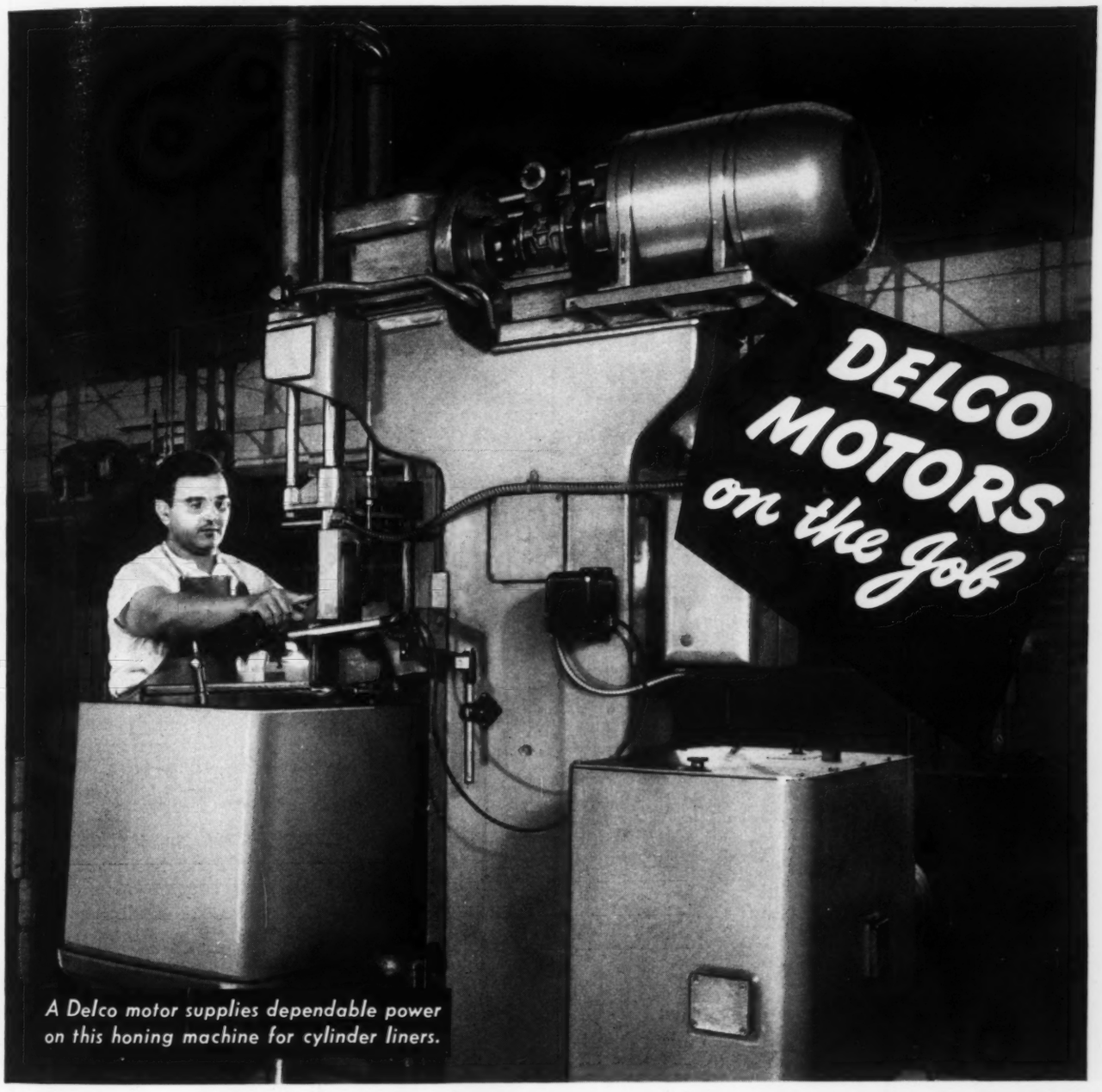
University of Michigan. While still an undergraduate, Professor Marin won three scholarships for highest standing in engineering.

His academic engagements included among others that of assistant professor of engineering materials at Rutgers university. His summers also were devoted to research and development, the last of these being in 1937 in the turbine division of Westinghouse Electric & Mfg. Co., Philadelphia. Among teaching activities he has given courses in drawing, mechanics, strength of materials, hydraulics, mechanics of materials and laboratory work in materials testing. He has also taught graduate courses in advanced mechanics of materials, mechanical properties of materials, theory of elasticity and applications, mechanical methods of stress analysis, and plasticity and creep of metals. Well known to readers of MACHINE DESIGN through his articles on stress analysis, Professor Marin has also presented various articles in other technical journals and has given papers on allied subjects before several engineering societies. He is a member of American Society of Mechanical Engineers, American Society for Testing Materials, American Society of Metals and Society for the Promotion of Engineering Education.

GRANTED to him "for his invention and development of the semiautomatic rifle which bears his name and has been adopted by the United States Army, and is a distinct contribution to our National Defense," John C. Garand of the Springfield Armory, Springfield, Mass., received the Holley medal which was instituted to be bestowed for some unique act of genius of engineering nature, that has accomplished a great and timely public benefit. Mr. Garand first submitted a design for a light machine gun to the Navy Department in 1916. He was then offered a job in the Bureau of Standards to develop his design and in 1919 was transferred to the Springfield Armory by the War Department to develop a semiautomatic rifle. After 20 years of persevering work he produced a rifle which was adopted as a standard weapon by the U. S. army in 1936 and recently by the U. S. Marine Corps.

♦

LOUIS B. NEUMILLER, who has been with the Caterpillar Tractor Co., Peoria, Ill., for 26 years,



A Delco motor supplies dependable power on this honing machine for cylinder liners.

STAMINA FOR THE "LONG HAUL"

Delco motors have the stamina to serve production well in the long haul ahead. They are built to stand up under heavy going . . . insulated for long-hour operation . . . designed for cool running . . . and dynamically balanced to reduce wear and contribute to the accuracy of the machining operation.

Put Delco motors to work on machine tool assignments. Consult the Delco Products Engineering Department for recommendations.

DELCO MOTORS

DIVISION OF GENERAL MOTORS CORPORATION

DELCO PRODUCTS
DAYTON, OHIO

100% PRODUCTION INCREASE Guaranteed the JETAL process

(PATENTED)

JETAL, the original patented method, is guaranteed to surpass any other method of blackening iron and steel in

- *SPEED*
- *WEAR RESISTANCE*
- *RUST RESISTANCE*
- *ECONOMY*

JETAL meets Government Specifications for a black oxide coating. With Jetoil, it withstands up to 50 hours' salt spray test.

JETAL *fulfills Defense needs—replaces strategic materials. Immediate delivery, any quantity. Send samples for JETALizing without charge. Consultation service without obligation.*

ALROSE CHEMICAL CO.
PROVIDENCE, R. I. TEL. WILLIAMS 3000

HERE'S A REAL LABOR SAVING DEVICE!

LEIMAN BROS. SAND BLAST

Removes scale—Cleans metals, Displaces Acid, & scratch brush—Quicker—More Uniform

Results in quicker machining of castings, quicker and more lasting plate, paint or enamel.

Used on metals, plastics, glass, bakelite, hard rubber and all materials.

LEIMAN BROS. INC.
152-2 Christie St.
Newark, N. J.

has been elected president, succeeding B. C. Heacock who becomes chairman of the executive committee. Mr. Neumiller began with the company as blueprint clerk in the engineering department and in the following years served in many capacities.

♦

EARL F. OYSTER, Cleveland, recently joined William H. Nicholls Co., Inc., Richmond Hill, Long Island, N. Y., as chief engineer. Mr. Oyster had been employed by the Alliance Machine Co., and more recently by the Osborn Mfg. Co., as mechanical engineer, later becoming chief engineer.

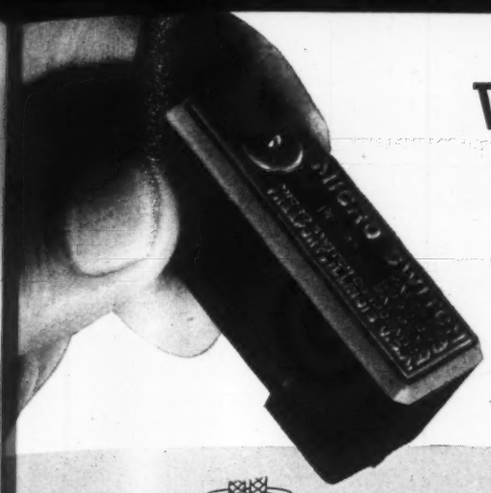
WIDELY-known hydraulics engineer and for the past three years staff engineer at Lockheed Aircraft Corp., Burbank, Calif., Wilbur G. Wood has been appointed chief engineer of Mensaco Mfg. Co. in its new hydraulic strut division. A mechanical engineering graduate of Purdue university, Mr. Wood has for the past 14 years devoted most of his attention to designing and supervising the development of landing gear. While a member of the engineering staff of Douglas Aircraft Co. he designed the landing gear for the 65,000 pound, four-motored leviathan of the air, the DC-4, at that time the world's biggest airplane and the first of the large planes to use tricycle landing gear. His first position in the aircraft industry was in July, 1927 when he joined the Consolidated Aircraft Corp., with headquarters in Buffalo, N. Y. Made project engineer on the Fleet trainer developed in 1929, he designed its landing gear as well as many other parts. He was placed in charge of wing design in 1932 for the company's first two-place, all-metal pursuit. In 1938 he accepted a position with Lockheed as hydraulic engineer, and served as consultant on all hydraulic landing gear designs and installations.

♦

WILLIAM F. LAMOREAUX, for many years vice president, general manager and director of Ducktown Chemical & Iron Co., has been appointed a director of research, Meehanite Corp., Pittsburgh.

♦

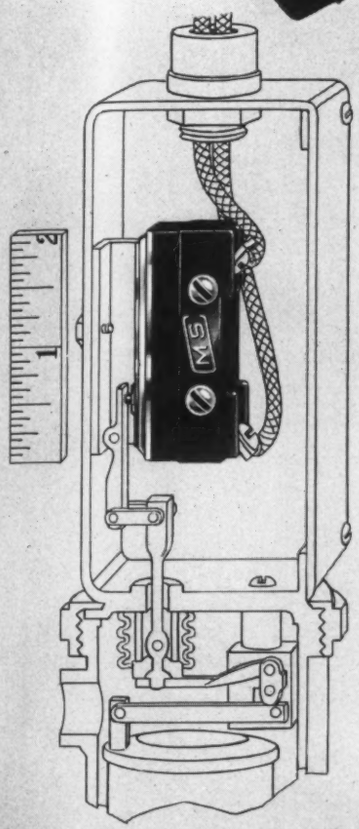
DR. JOHN BOSWELL WHITEHEAD has been awarded the Edison Medal for 1941 by the American Institute of Electrical Engineers "for his contributions to the field of electrical engineering, his



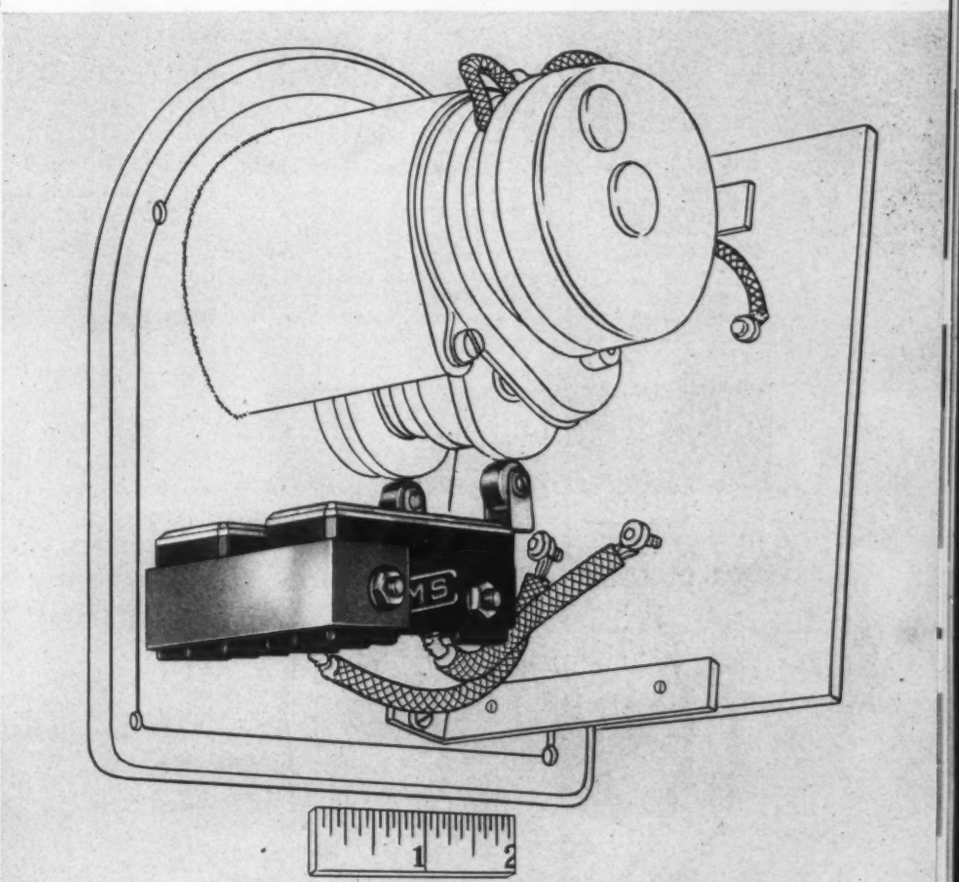
Whether it is Low Water Cut-Off or Electric Furnace Input . . . .

MICRO SWITCH

Solves the Problem of Small Space . . . Fast Action—Long-Lived Dependability



In its Water Boy Water Feeder and Low Water Cut-off, Maid-O-Mist, Inc., Chicago, combine dependable, long-lived signal and control in small space with a Micro Switch actuated by a series of levers connected to the water level float. The normally open Micro Switch closes the circuit when the float rises to a pre-determined level. It opens again when the float recedes to a certain water level. The switch used is Type YZ-RB, a complete description of which is found on page 1.03 of the new Micro Switch Catalog No. 60.



In their input controller for electric furnaces and heaters, Wheelco Instruments Company, Chicago, use two Micro Switches for simplicity of design, accurate and dependable control. The switches are actuated by cams which are adjustable from the outside to provide any desired combinations of on-and-off time control. The switches used here are Type BZ-RL25, fully described on page 1.04 of the new Micro Switch Catalog No. 60.

In both sensitive instruments and massive punch presses, you will find Micro Switch employed in countless ways to furnish millions of identical switch actions in a space no larger than your thumb.

If your product should be more compact, if it should better "deliver the goods," you should consider Micro Switch—its precise fast action, its ability to operate at exactly the same point each time for millions of operations—as a better and more economical switch for your purpose than any you yourself can design.

The Micro Switch measures only 11/16″ x 27/32″ x 1 15/16″—weighs only one ounce—and operates on forces as low as one ounce and movement differences as small as .0002″.

It is truly a David accomplishing a Goliath feat. It is listed by the Underwriters' Laboratories with ratings of 1200 VA loads from 125 to 600 volts A.C.

Micro Switch can be supplied in a wide variety of housings. Accurately moulded Bakelite with a color-coded Plaskon top for use where no protective housing is required—in steel with rugged actuators for heavy duty service—in die cast metal, sealed against dust, oil and water—in light weight aluminum for aircraft—and in heavy malleable iron for explosion-proof service. Each of these protective housings can be fitted with any one of a number of actuators, all designed to meet specific requirements.

The Micro Switch Handbook Catalog No. 60 contains complete descriptions of all of these housings and actuators, in addition to the wide range of electrical characteristics in which Micro Switch can be supplied. Send for this book and consult with Micro Switch engineers who are specialists in precision switching.

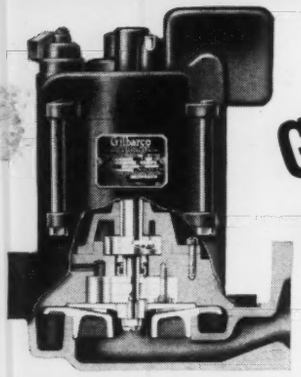
Copyright 1942, Micro Switch Corporation

Micro Switch is a trade name indicating manufacture by Micro Switch Corporation.

MICRO MS SWITCH

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation. Sales Offices: New York, Chicago, Boston

READY FOR IMMEDIATE DELIVERY



GILBARCO COOLANT PUMPS

● Standard equipment on many internationally known machine tools, the new Gilbarco Centrifugal Coolant Pump is now available in any quantities. Equipped with ¼ H.P. explosion-resisting motors for all voltages, including polyphase, 115 or 230 volts D. C. These dependable pumps will handle up to 15 gallons per minute. Durable—low in price—a product of one of the country's largest pump makers. Wire or write at once for descriptive bulletin and prices!

GILBERT & BARKER MFG. CO.
WEST SPRINGFIELD, MASS.

Worth Building Your Whole Machine Around!

Janette Motorized Speed Reducers

Manufacturers who seek to make their motor driven, slow speed machines more compact, efficient, attractive and reliable, can do so by using one or more of the 43 sizes of Janette speed reducers.

MORE COMPACT because the motor and gear box are ONE unit, scarcely larger than a motor alone.

MORE EFFICIENT because your machine will be more solid and simple in construction; have uniform delivery of power and permanent alignment of gears and shafts.

MORE ATTRACTIVE because the handsome finish, excellent construction and compactness will add neatness and better appearance to any machine. Unsightly belts and pulleys are eliminated.

MORE RELIABLE because Janette builds both motors and gear boxes and there is no divided responsibility for their successful operation.

In addition the production and assembly of your machine are simplified, which makes your product more saleable at lower cost. MAY WE SEND YOU OUR 100 PAGE CATALOG.

Janette Manufacturing Company
556-558 West Monroe Street Chicago, Ill. U.S.A.

pioneering and development in the field of dielectric research, and his achievement in the advancement of engineering education." Dr. Whitehead is professor of electrical engineering and director of the school of engineering, The Johns Hopkins university.

♦

DR. HOWARD E. FRITZ, formerly manager of the synthetics division of The B. F. Goodrich Co., has been named director of research succeeding JAMES W. SCHADE, retired. Before joining Goodrich Dr. Fritz was a member of the faculty of the engineering school at Ohio State university.

♦

BRUCE R. PRENTICE, who entered the employ of General Electric as a student engineer and has worked on aircraft armament controls in the aeronautics division, has been promoted to engineer, aeronautics equipment division of the company. KENNETH K. BOWMAN has been made assistant engineer of the aeronautics division, and HARLEY H. BIXLER, mechanical engineer on special assignments.

♦

GEORGE J. HIGGINS has been appointed full professor and director of the department of aeronautical engineering of the University of Detroit. Heretofore he was acting director and associate professor. Prior to his appointment to the faculty, he had been associate aeronautical engineer in the National Advisory Committee for Aeronautics, and was in charge of the variable density wind tunnel at Langley Field.

♦

ARTHUR F. VAN DYCK has been elected to the presidency of the Institute of Radio Engineers. He is associated with the Radio Corp. of America.

♦

THEODOR VON KARMAN, director of the Guggenheim Laboratory of the California Institute of Technology, received the American Society of Mechanical Engineers medal for 1941. A consultant of the material division of the U. S. Army Air Corps, Mr. von Karman received the award for "his brilliance as a teacher, his researches in elasticity and many fields of physics and mechanics, and his distinguished leadership in the fields of aerodynamics of aircraft design."

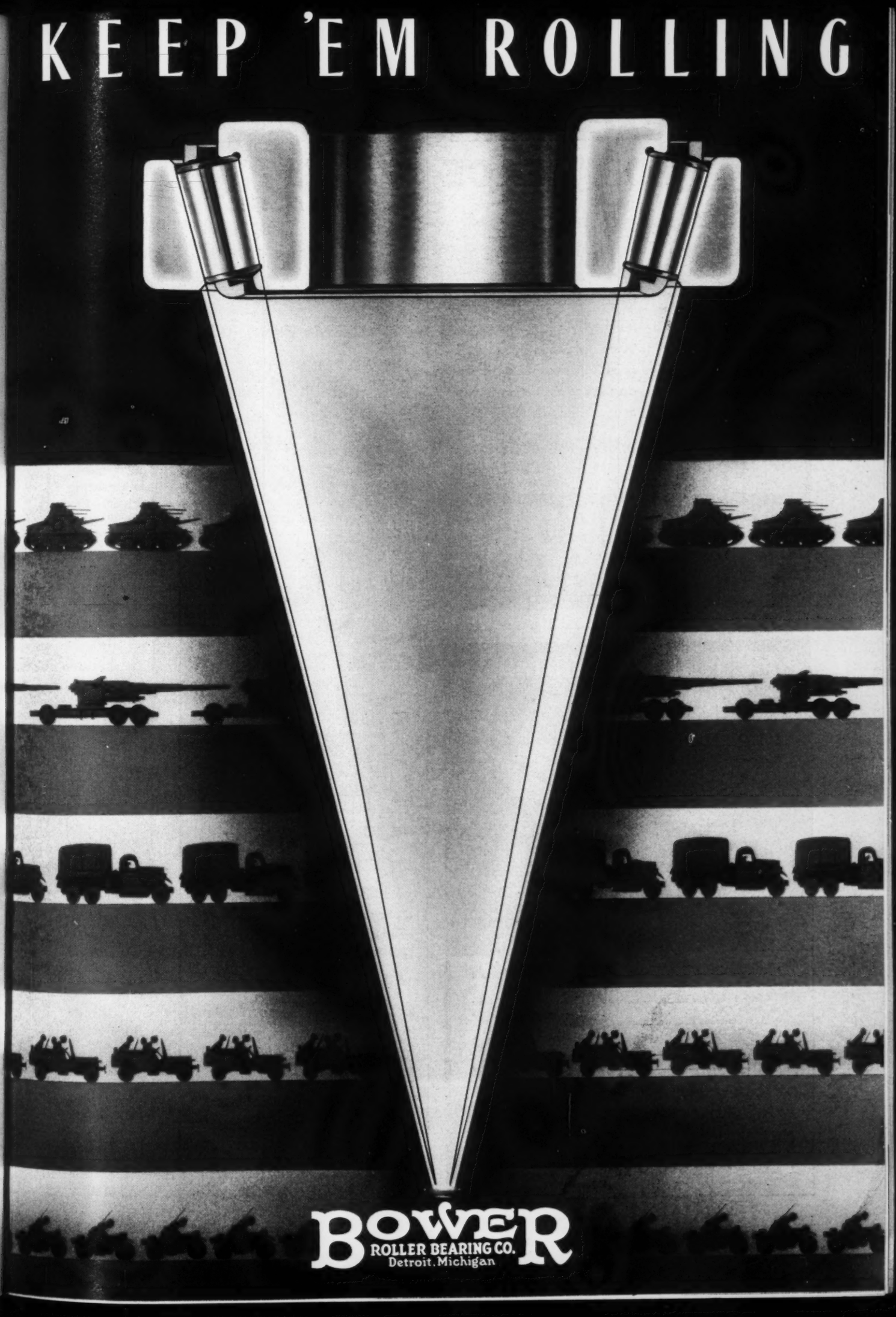
♦

A. W. HERRINGTON was recently elected president of the Society of Automotive Engineers. Mr. Herrington is president of Marmon-Herrington Co. Inc., Indianapolis.

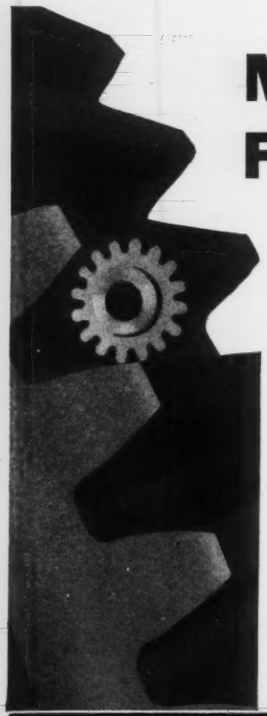
♦

J. HARRY JACKSON has been appointed a research engineer on the technical staff of Battelle Memorial institute, Columbus, O. Prior to joining the Battelle staff he was associated with Caterpillar Tractor company for five years as metallurgist and welding engineer.

KEEP 'EM ROLLING



BOWER
ROLLER BEARING CO.
Detroit, Michigan



MACHINERY FOR PEACE

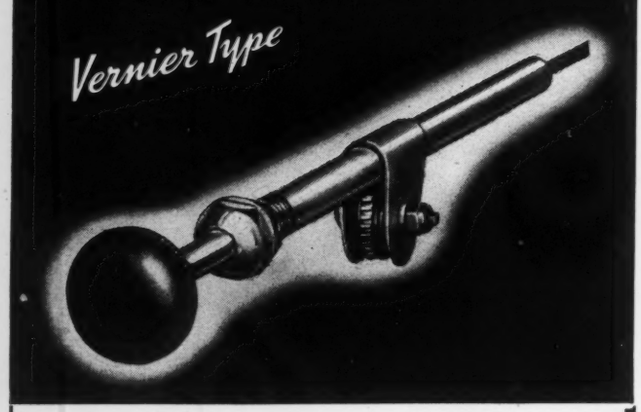
In making gears for airplanes and other machinery of War—we know we are building for a Peace that must come.

Then perhaps you will permit us to work with you on the requirements for an even better world.

DIEFENDORF GEAR CORP.
SYRACUSE, N. Y.

DIEFENDORF • GEARS

ARENS REMOTE CONTROLS



DEPENDABLE . . . Arens' Vernier Type Remote Control Head gives coarse *and* micro-fine adjustments.

Control position cannot slip . . . it is always in mesh. Like all Arens Controls . . . the Vernier Type is built with highest quality materials and workmanship for lasting precision.

CROSS-SECTION

WRITE FOR COMPLETE CATALOG
Arens engineers will gladly assist you in any specialized remote control problem.

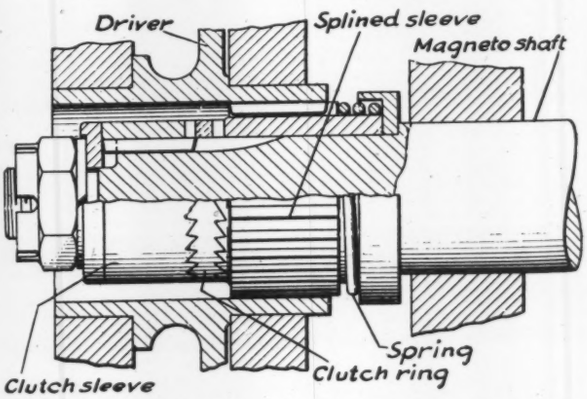
ARENS CONTROLS, INC.
2256 So. Halsted Street • Chicago, Illinois

IT'S UNDER PERFECT CONTROL IF IT'S ARENS

Noteworthy PATENTS

Affords Vernier Adjustment

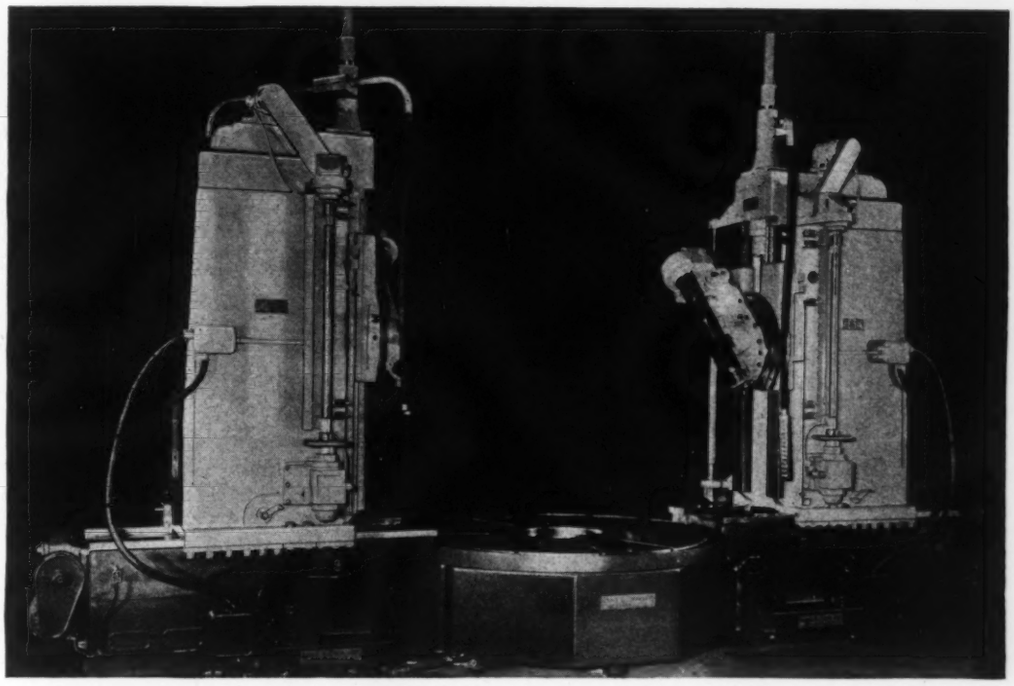
IN COUPLING magnetos to modern, high-powered, multicylinder engines it is essential, in order to attain proper timing, to position accurately the angular relationship between the magneto shaft and the driving element on the engine. Heretofore this has been accomplished in two ways. First, by means of an externally splined sleeve fastened to the magneto shaft and co-operating with an internally splined sleeve on the driver. Extremely rough adjustments equal to the angle subtended by the pitch of the spline are obtained. A second method provides for the adjustment of the magneto stator with respect to the rotor. This methods requires that the designer provide considerable space for adjustment. Once the adjustment has been made such space is of no further use and might be considered to be wasted. In a patent assigned to the Bendix Aviation Corp. both of these objections have been overcome and extremely fine adjustments are possible.



Form of clutch teeth, unit difference in their number make possible easy and precise angular adjustment of one shaft with respect to another

Driver or power takeoff from the engine contains the conventional internally splined ring. This spline engages a splined sleeve which is mounted freely on the magneto shaft. The left face of this sleeve is formed with clutch teeth as indicated in the illustration. A clutch ring with mating teeth also floats on the shaft adjacent to the sleeve. The left side of the clutch ring also has teeth, similar

ACCURACY *was the first consideration*



. . . . . So GOULD & EBERHARDT SELECTED NORMA-HOFFMANN PRECISION BEARINGS

Pictured here is the 120H Gear Hobber, designed and built by Gould & Eberhardt (Newark, N. J.) for the accurate production of marine turbine reduction gears up to 160-inches diameter. NORMA-HOFFMANN PRECISION BEARINGS are used for the main index-worms, and the manufacturer writes:

"These bearings . . . . were selected because of the extreme precision required. In a gear hobbing machine, it is very important that there be no end-play of the index-worms and, more particularly, no end-camming motion. The ball bearings must therefore of necessity be held within extremely close tolerances."

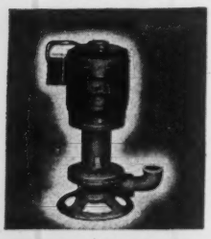
This is but one of the many instances in which NORMA-HOFFMANN PRECISION BEARINGS are contributing to the accuracy and dependability of the machines that are setting new production records under the "Victory Program". There is a NORMA-HOFFMANN PRECISION BEARING for every load, speed and duty.

Write for the Catalog. Let our engineers work with you.

NORMA-HOFFMANN BEARINGS CORP'N., STAMFORD, CONN., U. S. A.
FOUNDED 1911

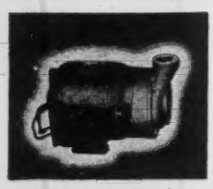
PRECISION BALL, ROLLER and THRUST BEARINGS

BRADY - PENROD
Centrifugal
COOLANT PUMPS
AS HIGH AS 70% HYDRAULIC EFFICIENCY



Keep machines going - production high, use BRADY-PENROD Coolant and Circulatory Pumps, motor driven.

We will design special pumps to meet your requirements or special mounting brackets that will fit our pumps to your machine. Equal efficiency maintained pumping water or light oil. Five models available with separate rating established at 400 SSU; 750 SSU; 1250 SSU; 2000 SSU.



⅛ H.P. Motor Replaces ¼ H.P. through superior pump design. All motors have 20% surplus power.

CAPACITIES: ½ to 2" pipe; 4 to 100 gallons per minute. Special models for larger capacities. Pressure up to 100 feet head.

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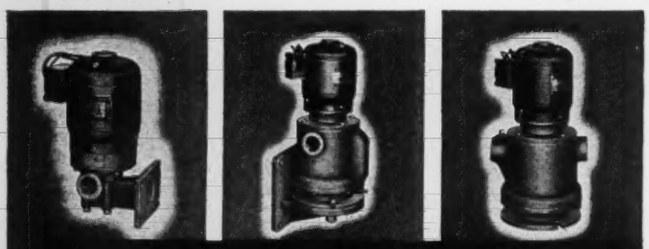
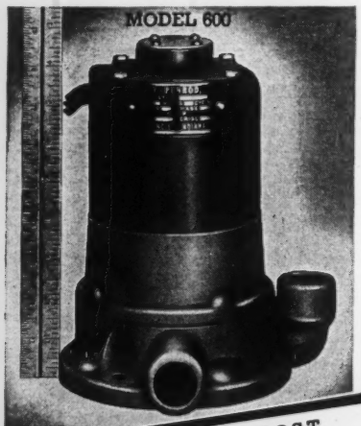


BRADY - PENROD, INC.
1216 W. SECOND ST., MUNCIE, INDIANA.

BRADY - PENROD
Replacement
Centrifugal
COOLANT PUMPS!

Eliminate time lost - keep machines operating full force - for replacement pumps, use -



BRADY-PENROD Coolant and Circulatory pumps - motor driven open impeller centrifugal type.

Bolting pumps to machines is unnecessary, pipe connections alone are usually sufficient.

LOW COST
Capacities are automatically controlled by pipe sizes ranging from ⅜" copper tubing with 1 gal. per min. to 1" pipe with 20 gal. per min. - using ⅛ H.P. Motor. 220 V. 3ph. 60 cycle.
$40

BRADY - PENROD, INC.
1216 W. SECOND ST., MUNCIE, INDIANA.

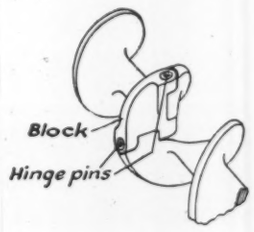
in form to those on the sleeve but differing in total number by one. This second set of teeth engages with similar teeth formed on a clutch sleeve which is capable of being locked to the magneto shaft.

When an adjustment is necessary the locking nut on the left end of the magneto shaft is backed off an amount equal to slightly more than the depth of one of the clutch teeth. The compression spring then induces the complete clutch assembly to follow the nut holding the clutch teeth in engagement. In this position, if the magneto shaft is rotated slightly clockwise, the teeth on the left face of the clutch ring will exert a camming action on the clutch sleeve. When the amount of rotation equals the pitch of one of these teeth the clutch ring under the impetus of the spring will snap back into engagement with a definite click. If the magneto shaft is then rotated slightly in the opposite direction, that is, counterclockwise, a similar action takes place between the clutch ring and the spline sleeve. Because the number of teeth in the spline sleeve and the clutch sleeve differ by one the total net adjustment of the magneto shaft with respect to the driver equals the difference between the pitch of one tooth on the splined sleeve and a tooth on the clutch sleeve.

In an actual coupling in which the diameter of the sleeves is approximately one inch, one face of the clutch ring is provided with twenty-three teeth and the other side with twenty-four teeth. Thus after an oscillation of the magneto shaft an angular adjustment of two-thirds of one degree was possible with this unit. Of course, by increasing the total number of teeth on each side of the ring but maintaining the difference of one tooth between the numbers, an even finer adjustment would be possible.

Travels around Corners

IN THE design of materials handling equipment utilizing screw-type conveyors it is often inexpedient to design the conveyors for a straight run from the source of material to its point of delivery. This is particularly true in the case of screw conveyors used to take coal from a tender to supply



Built-in universal joint permits angular displacement of sections of conveyor

the fire box of a steam locomotive. In going around curves it is apparent that some jointed connection is required in the conveyor. Also in the case of inordinately long conveyors the screw by reason of its own weight may sag and bind in its channel. Frequently interspersed universal con-

(*Continued on Page* 138)

MAGNETIC MOTOR CONTROLS

ACROSS-THE-LINE TYPE

Full range for motors up to 50 H.P.

RELAYS — Midget size: Very fast action with *no residual magnetism* permits closer range of timing; important advantage in machine tool control and in welding. Silver to silver contacts, stationary and moving both removable from the front. Impregnated coil; complete dampproof insulation. Engineered for exceptionally long life. Rated up to 440 Volts; contact rating 10 amperes, A. C. Industrial control spacing. Available with or without NEMA Type 1 enclosure; also for panelboard mounting.

SOLENOID STARTERS — Sizes 0 and 1: For control of motors of 1 to 7½ H. P., single or polyphase. A. C., 110 to 550 Volts. Front-connected, with open view for inspection of contacts and connections. Coils, contacts and other parts easily changed. Switch unit removed or replaced by turning *one screw* only. Re-set button independent of cover. Separate-unit construction for *each pole,* — confining the arc, excluding dust. This lighter, stronger build of switch reduces impact, conduces to long life.

MAGNETIC CONTROLS — Sizes 2 and 3: Double-break silver to silver contacts, full-floating and self-aligning. Individual arcing chambers for each pole. Magnet E-shaped, with heavy-duty shading coil. Interchangeable heaters. All replacement parts accessible from front of switch; handy straight in-and-out wiring. Three types of enclosures: general purpose, weatherproof and for hazardous locations. For quick reference to the standard units, ask for Catalog 8-M.

INDUSTRIAL CONTROL DIVISION

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

"CHACE HIGH-TEMPERATURE Thermostatic BIMETAL

Used IN THE New MERCOID TYPE 41 Limit Control"

THE MERCOID CORPORATION, CHICAGO, ILLINOIS

This Mercoid Limit Control is designed to protect the furnace from overheating. A new feature is the outside adjustment located in center, on front of instrument. This adjustment facilitates setting of operating range. To insure positive and uniform action of this control, Chace High-Temperature Thermostatic Bimetal is used for the actuating element. Whenever automatic action is desired at some pre-determined temperature, always specify Chace Bimetal for reliable, uniform movement. Sheets, strips and finished parts for your assembly.

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New Transmission Catalog and Handbook

Gives Full Details on

VARIABLE SPEED PULLEYS
A new sales feature for your machines:—variable speed at the turn of a wheel. V-Belt and Wide V-Belt types. Sizes up to 8 H.P. Low cost.

VARIABLE SPEED TRANSMISSION
Ideal "Select-O-Speed". Infinitely variable speed selection over wide ratio. Smooth, dependable, low cost.

AUTOMATIC TENSION CONTROL MOTOR BASE
Install in place of motor rails. Permits low cost, short center drives.

Complete recommendations, application data and engineering information.

FREE A quick index source of reference. Includes complete data on Ideal Variable Speed Control Equipment:—sizes, rated capacities, description of outstanding features, where applicable, how installed, etc.

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"Sales Offices in all Principal Cities"

(*Continued from Page* 132)

nections between sections of the conveyor would obviate this difficulty. Such a universal connection is the subject of a patent assigned to The Standard Stoker Co.

Method of accomplishing the objective is simple, as shown in the illustration. Adjacent ends of two sections of a screw conveyor are connected together by means of a quadrant block. This block is attached to one conveyor by means of a hinge pin and to the other by a second hinge pin at an angle of ninety degrees to the first. In order to cause as little as possible obstruction to the flow of the material being handled the hinge block must be so shaped as to conform as closely as possible to the conveyor screw surfaces. Also, lateral displacement of one conveyor section with respect to the other is undesirable. For these reasons the hinge pins should lie in the same plane perpendicular to the axis of the conveyor when its sections are not angularly displaced.

Channel Jointed

In the present invention, intended primarily to be applied to railroad service where the angle between the element of the conveyor must be variable, it is provided that each section of the screw conveyor be enclosed in its own cylindrical channel. These channels are then articulated in a section adjacent the universal joint by means of a ball and socket connection.

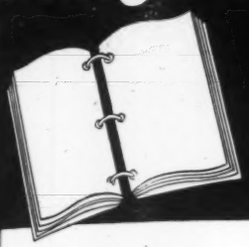
Examination of the illustration will disclose that for a constant angular velocity of the driving screw about its own axis the corresponding angular velocity of the driven screw will not be constant. Such conveyors are, however, normally operated at low speeds and this objection usually will be of no disadvantage to its operation.

Corrects for Temperature and Voltage

ERRORS introduced by reason of variations in ambient temperature as well as impressed voltage may cause faulty readings of electrical liquid level gages of the kind normally used in the gasoline tanks of automobiles. In a patent assigned to Anderson Co. errors arising from these two sources are compensated by means of two bimetal coils, controlling the resistance of the circuit.

A float is so attached to the end of the lever arm that the rise or fall of the liquid level in a tank rotates a bevel gear. This gear in turn rotates through a bevel pinion a vertical shaft. Fastened to the upper end of this shaft is an ambient temperature bimetal coil, the upper end of which carries a rheostat. Bearing on the rheostat winding is a contact arm affixed to the lower end of a voltage responsive bimetal coil, the other end of which is fastened to one of the electrical terminals. Suspended from the second terminal down through the axis of the bimetal helix is a heater coil which

Designing Molded Plastics Parts: WALL THICKNESS



from the engineering files of One Plastics Avenue

When planning wall thicknesses of molded plastics parts the following general factors should be considered:

1. To obtain lowest manufacturing costs use minimum thickness that can be employed to produce a satisfactory part. Thin sections speed molding cycle and cut cost of material.

2. In any given part make walls of uniform thickness to eliminate uneven shrinkages and resultant stresses.

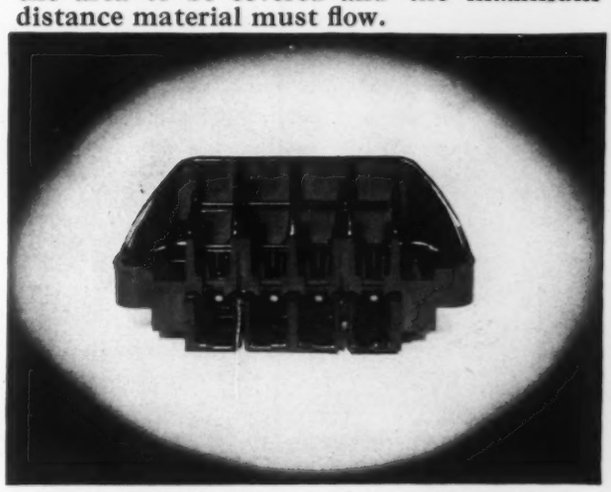
3. When both thick and thin sections are used in a molded piece the thick section should have holes or be cored to promote uniform curing.

4. Best moldings are designed so that thickness of section does not increase as it nears the flash line.

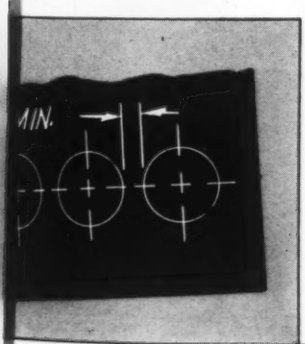
5. Fabric filled phenolic materials require heavier sections for finished parts.

INJECTION MOLDING

Thin walled sections chill quickly and neutralize injection pressure. Avoid sections of less than .050″ unless paths of material travel are short and high pressures are available. In all cases .020″ is minimum wall thickness. G-E Mycalex parts should have a wall thickness of at least 1/16″, increasing with size of part. In practice, minimum thickness is governed by the area to be covered and the maximum distance material must flow.



TYPICAL APPLICATION Compression molded part for electric meter showing uniform thickness and slight taper of wall sections.

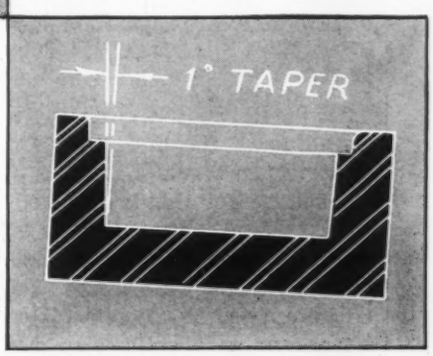


◄ THICKNESSES AROUND HOLES AND INSERTS

Thickness of material between insert and wall of any hole should be a minimum of 1/16″, between any two holes at least 1/8″.

STANDARDS ►

ally accepted minimum wall ess for average small parts is for larger parts such as radio ts 1/4″. Urea plastics may be or such applications as lighting ons with minimum wall thick- of .035″ and maximum thick- of .125″. Average for general .050″. As the thickness of n increases the transverse h and dielectric strength de- Design vertical walls with r taper of 1° per side to facili- moval from mold. 1/2° is the m practical draft.



ADDITIONAL FACTS Requirements for wall thickness vary with the type of material used in the molded part and with the application. G.E.'s consulting engineering service will advise you on best methods of design.

ONE PLASTICS AVENUE at Pittsfield, Massachusetts, is the headquarters for five plants of the Plastics Department of General Electric Company. It signifies the location of complete plastics facilities for development, material manufacture, designing, engineering, moldmaking, molding and laminating.

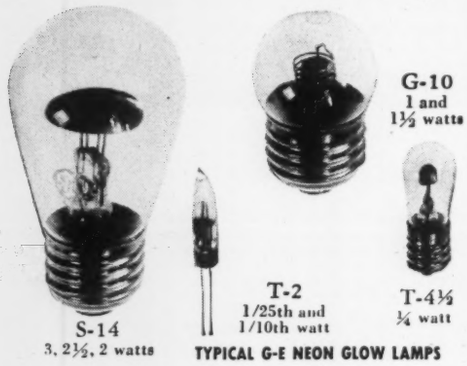
REPRINTS of this advertisement may be obtained by writing Section D-2, General Electric Plastics Department, Pittsfield, Mass.

PLASTICS DEPARTMENT

GENERAL ELECTRIC

1D-14

WILL A G-E NEON GLOW LAMP SOLVE YOUR DESIGN PROBLEM?



S-14
3, 2½, 2 watts

G-10
1 and
1½ watts

T-2
1/25th and
1/10th watt

T-4½
¼ watt

TYPICAL G-E NEON GLOW LAMPS

G-E NEON GLOW LAMPS, rugged and economical, have made hundreds of electrical products more convenient, more useful, more attractive, safer. Excellent for pilot and indicator lights and scores of other uses.

YOUR ELECTRICAL WHOLESALER can supply the complete line of these handy lamps. For a folder on G-E Neon Glow Lamps write the address below.

NELA SPECIALTY DIVISION, LAMP DEPT.

GENERAL ELECTRIC

410 EIGHTH STREET, HOBOKEN, N. J.

NEW CATALOG K-15 of KEYSTONE INDUSTRIAL BRUSHES

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The new Catalog K-15 of Keystone Carbon, Graphite, and Metal-Graphite Brushes illustrates many popular types of ring and commutator brushes. Base prices of standard sizes are listed and a simple method of computing prices for each style is given. Send for your copy of this valuable catalog today—no cost or obligation.

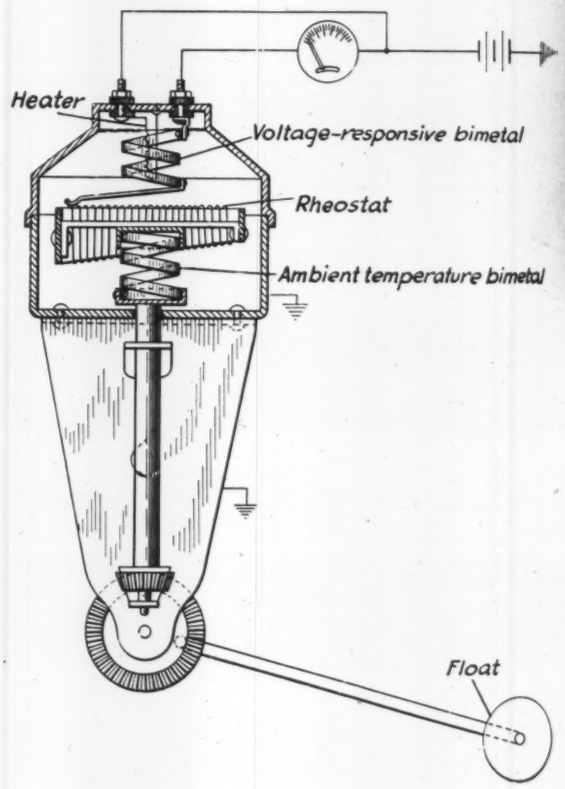
KEYSTONE CARBON CO., INC.

1935 STATE ST. SAINT MARYS, PENNA.

is grounded on the casing to complete the circuit.

As the float rises in response to an increasing liquid level the rheostat tends to rotate in the direction of decreasing the resistance of the circuit, thereby causing the ammeter indicator to show an increase in reading. However, the ambient temperature bimetal, serving as the intermediate connection between the shaft and the rheostat, tends to modify this rotation in response to temperature. For example, if the ambient temperature increases the resistance of the rheostat will also increase. However, the change in temperature acting upon the ambient temperature bimetal affects a correction by rotating the rheostat in the direction of reducing the resistance.

If the voltage applied to the instrument should decrease this normally would result in less current



Two bimetal helices compensate for changes in both ambient temperature and impressed voltage in electric liquid level gage

flowing through the circuit and hence in a lower reading of the indicator. Conversely an increase in voltage would have the opposite effect. Compensation for this is achieved by the upper bimetal helix. For example, if the voltage increases more current flows through the heater coil down through the center of this helix. The increase in temperature applied to the bimetal tends to move the contact arm in the direction of increasing the resistance of the circuit. Thus instead of showing an increase in indicator reading the current is adjusted downward despite an increase in voltage, so that the indicator reads the exact level of liquid in the tank.

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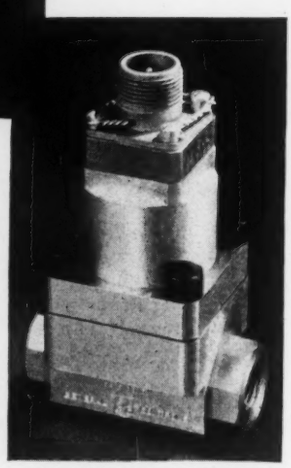

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By John Delmonte, Technical Director of the Plastics Industries Technical Institute; second edition, published by Penton Publishing Co., Cleveland; 601 pages, 6 by 9 inches, clothbound, available through MACHINE DESIGN *for $7.50 postpaid.*

If you have felt the lack of an authoritative and all-encompassing engineering reference on the subject of plastics, this book is an emphatic "must." Revised, rearranged and expanded, even more stress has been placed upon physical properties and other characteristics of plastics vital to the work of engineering designers than in the first edition which was so well received.

In order to increase the utility of the book in connection with the aforementioned engineering data and new developments in the field, those portions devoted to the pure chemistry of plastics have been condensed. New chapters are included and technical data reorganized to permit easier reference. Extruded plastics and resin-bonded plywoods, for example, are given much more prominence because of the tremendous recent expansion in these developments. Also, a chapter on extrusion has been added.

Delmonte's book is one of the "MACHINE DESIGN series." The author is a recognized authority and is well known to readers of this journal through his pertinent articles on the various phases of plastics application in machines.

□ □ □

Hydraulic Measurements

By Herbert Addison, Professor of Hydraulics at the Fuad I, University, Giza, Egypt; published by John Wiley & Sons, Inc., New York, 301 pages, 5½ by 8½ inches, clothbound, available through MACHINE DESIGN *for $5.00 postpaid.*

An excellent and well-written book on a subject not covered exclusively and specifically in any other volume. Differing from other works on flow measurements this deals with liquids only. When fundamental principles are being expounded it is undoubtedly advantageous to study fluids as a whole, including both gases and liquids. However, an individual engineer faced with a specific problem such as gaging the flow of a particular liquid in a particular pipe does not want to be confused with the additional complexities that the measurements of elastic fluids involve.

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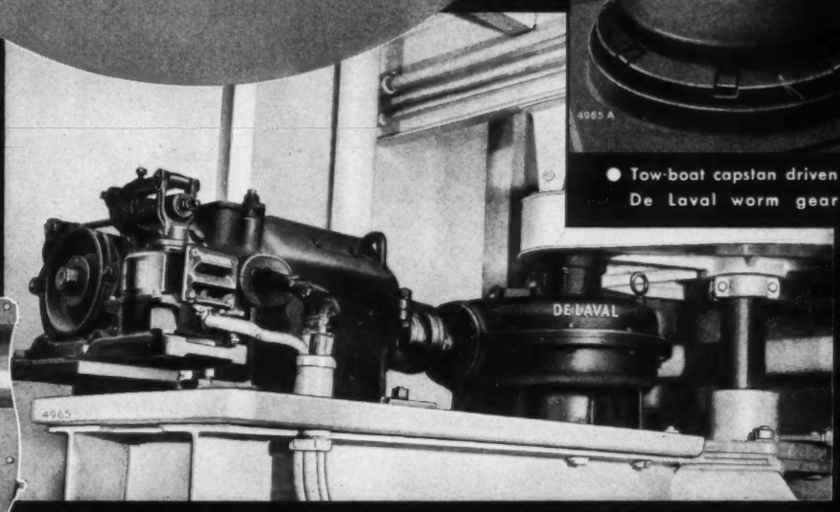

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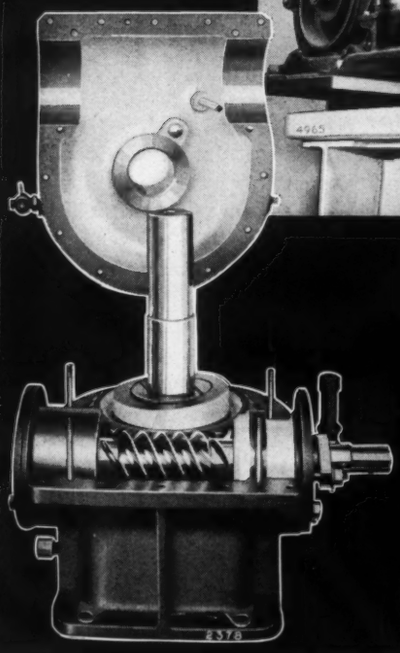

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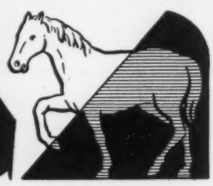

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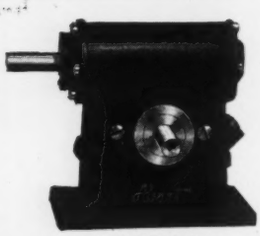

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subjects of the technique and instruments of fluid measurement, engineers are far from being in agreement. Rather, contradictory opinions are expressed and maintained with a warmth associated ordinarily with political convictions. Nor are these conflicting views unreasonable when it is realized that the measurement of liquids is as much an art as a science, and that the worth of the figures that purport to represent the flow can only properly be assessed when the experience, skill, and reputation of the observers and of their chief are known.

The book itself is intended to be a wholly practical work so as to be of the greatest utility to those actually engaged in making hydraulic measurements. Although some elementary knowledge of hydraulic principles is assumed, a glossary has been prepared for readers who have specialized in other branches of engineering. Frequent use of metric units and the comprehensive table of conversion factors give a clear indication of the author's preferences. As he states, "Water measurements especially show up the unhandiness of the foot and the pound in comparison with the facile interchangeability of the liter and the kilogram."

□ □ □

Handbook of Chemistry and Physics

By Charles D. Hodgman and Harry N. Holmes; 25th edition, published by Chemical Rubber Publishing Co., Cleveland, 2,503 pages, 5 by 7¼ inches, flexible clothbound, available through MACHINE DESIGN *for* $3.50 *postpaid.*

Presentation of this new edition has been motivated by the desirability of having in condensed form as large an amount of accurate, reliable and up-to-date information in the fields of chemistry and physics as is consistent with convenience and utility. The general features and arrangement used in former editions have been retained. An attempt has been made to include material which would be likely to find extended use. However, in order to retain the convenience of moderate dimensions and at the same time encompass the extension of knowledge in the sciences of physics and chemistry, it has been necessary in some cases to exclude material of use only in certain highly specialized lines of work.

Since the standardization of the millibar as a unit of pressure by the United States Weather bureau, comprehensive conversion tables, from pressures in inches or centimeters of mercury to millibars, have been included. Also the list of letter symbols and abbreviations has been revised in accordance with the recommendation of the Committee of the American Association of Physics Teachers. A table of natural secants and cosecants has been added to the mathematical section, affording an added convenience in machine computation.

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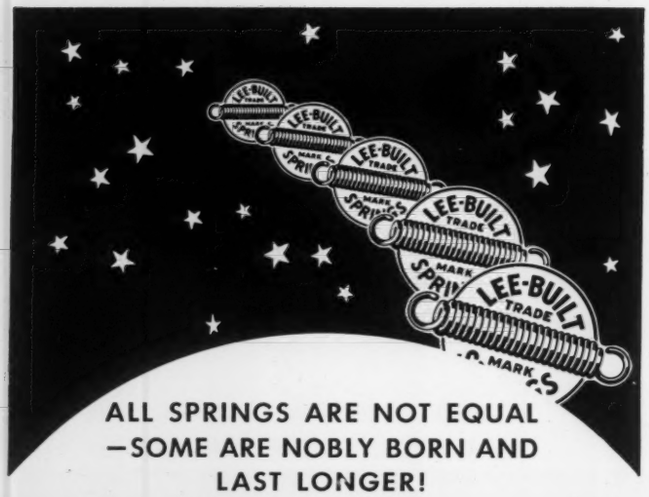

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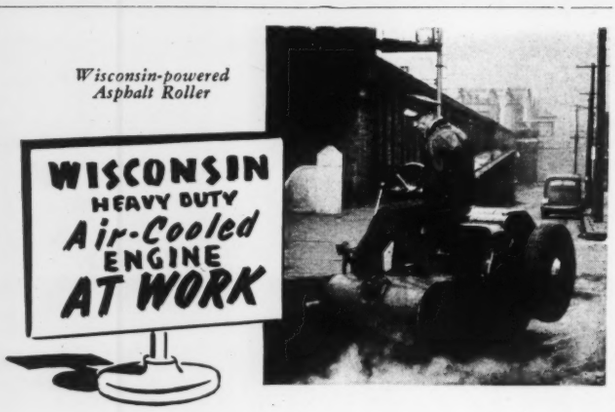

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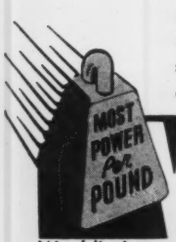

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Mobility Method for Shaft Vibration

(*Continued from Page* 65)

which frequency makes the mobility infinite. A useful clue lies in the important fact that the mobility changes sign in passing through infinity.

It is to be noted that this analysis is direct. Numerical computations follow immediately after the circuit diagram is drawn. Friction can be included, as was done in the case of the torsion pendulum. Generally speaking, however, bearing and gear teeth friction is so small in the usual gear system that it can be neglected. This results in a considerable simplification in the computation.

Illustrated by Example

As a numerical example, consider a gear system as shown in *Fig.* 7*a*. Mass 1 is a circular disk 50 inches in diameter weighing 1000 pounds. Mass 6 is a circular disk 75 inches in diameter weighing 8000 pounds. Shaft 2 is 60 inches long with a diameter of 4 inches. Shaft 5 is 15 inches long with a diameter of 4 inches. Assume steel shafts, with $G = 11.5 \times 10^6$ pounds per square inch, and assume the inertias of gears 3 and 4 to be so small as to be negligible in comparison with masses 1 and 6. The gear ratio $n = 2$. In this case $1/Z_3 = 0$ and $1/Z_4 = 0$. Equation 5 then becomes

$$Z_E = \frac{Z_1[Z_2 + n^2(Z_2 Z_6)]}{Z_2 + n^2(Z_5 + Z_6) + Z_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The denominator in Equation 7 is set equal to 0 to find the natural frequency of vibration. Substituting values for the mobilities gives

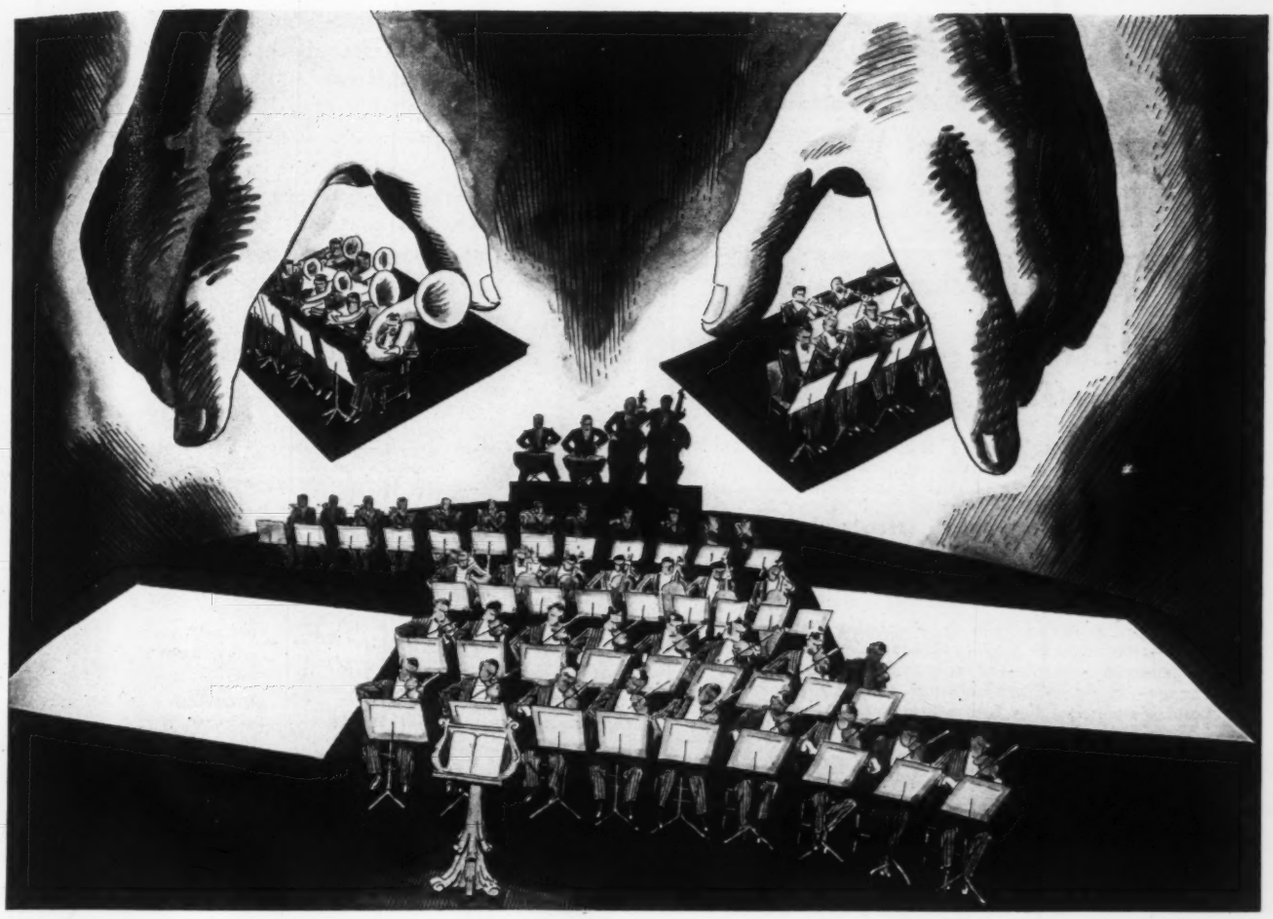
$$f_c = \frac{1}{2\pi}\sqrt{\frac{4I_1 + I_6}{I_6 I_1 (l_2 + 4l_5)}} \text{ cycles per second} \quad \ldots\ldots (8)$$

$$l_2 = \frac{32(60)}{\pi(4)^4 11.5 \times 10^6} \qquad l_5 = \frac{32(15)}{\pi(4)^4 11.5 \times 10^6}$$

$$I_6 = \frac{8000(75)^2}{8(386)} \qquad I_1 = \frac{1000(50)^2}{8(386)}$$

Inserting the numerical values in Equation 8 gives $f_c = 9.8$ cycles per second as the natural frequency of vibration of the system.

Cyclic gear trains can be treated in the same manner as simple trains. With cyclic trains there may be a question regarding the structure of the arm. An arm may act as both a spring and a mass. The problem of which pure elements should be substituted for the arm depends upon the particular construction involved. A cyclic train may give a steadier motion than a simple train, even though



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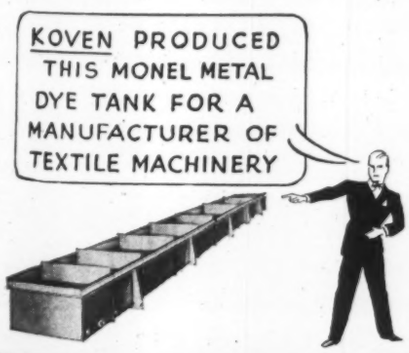

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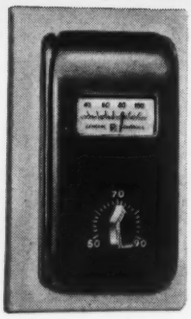

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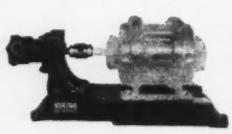

Fig. 61—Hydraulic motor driven pump. Sizes from 5 to 45 GPM. They are furnished complete with bracket and base, ready to receive, or complete with power—direct connected to 1200 RPM motor by flexible coupling. May also be equipped for gas engine or V-belt drive, if desired. Complete information in Bulletin 303. Write for it.

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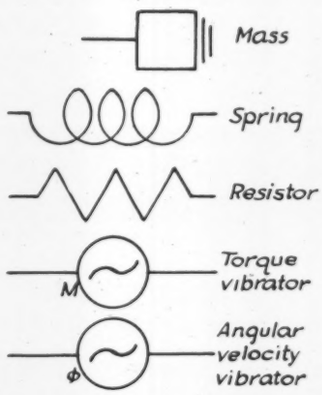
the cyclic train is a more complicated structure.

General treatment for all types of tooth irregularities involves numerous analytical difficulties. A case, which is probably one of the most pertinent types, will be discussed for the turntable drive shown in *Fig.* 8*a*.

Assume that the gears are rigid, and that the teeth are always in contact. There would be a constant relation between the angular speeds of the

TABLE III

Symbols for Elements



gears if the teeth were perfect. Suppose, however, that there are gear imperfections (as due to wear or other causes) which cause a definite change in the relative velocity. As a first approximation, take this velocity irregularity as sinusoidal (the first

Nomenclature

$j = \sqrt{-1}$
θ = angular displacement, radians
ϕ = angular velocity *across* a mechanical element, radians per second
M = torque *through* an element, pound-inches
$Z = \phi/M$ = torsional mobility, a complex ratio, radians per second per pound-inch
l = torsional compliance of an element, angular displacement per unit torque, reciprocal of torsional spring constant, radians per pound-inch
I = moment of inertia of an element, pound-inch per second per second
f = frequency of vibration $= \omega/2\pi$, cycles per second
ω = circular or angular frequency $= 2\pi f$, radians per second
t = time, seconds
r = torsional responsiveness of a resistor, angular velocity per unit damping torque, reciprocal of torsional damping constant, same units as mobility
n = gear ratio
G = modulus of elasticity in shear
g = 32.2 feet per second per second.

sine term of a Fourier series). *Fig.* 8*b* shows the schematic diagram. There is no change in the torque through the velocity vibrator.

Consider the case for the tooth frequency of 200 cycles per second for the data given in *Fig.* 8*a*. Calculation of the mobilities at A, B and C, together with a use of the mobility ratio, shows that the

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torque amplitude for the turntable 6 is about .00000082 times the torque amplitude through or at the vibrator. The velocity amplitude across the turntable is about .00014 times the velocity amplitude of the vibrator. Filtering effect at this frequency is rather large. The behavior of the system at other frequencies, and the effect of adding additional elements, can be studied directly in this manner.

In conclusion, the assumptions involved in this treatment are reasonable for a good number of important, practical cases. The mobility method offers for these cases a direct, convenient analysis technique which is particularly useful for numerical computations for complicated systems. While this present study is limited to torsional vibrations, it should be noted that the same method can be applied to other mechanical and fluid vibration problems.

Isolating Vibration through Use of Rubber

(*Continued from Page* 81)

not be subjected to temperatures above 150 degrees Fahr. Sometimes both results can be accomplished by extending arms or brackets outwardly from a machine to the mountings which can be favorably located. In some types of applications (such as underneath railroad passenger cars) it may be impossible to observe the dynamic behavior of resiliently mounted units. By the use of pry bars, however, it may be possible to force such a unit into the position of its maximum deflection so as to study the stress on the mountings and also the clearances between parts of mechanism, foundation, etc.

Records Show Floor Vibrations

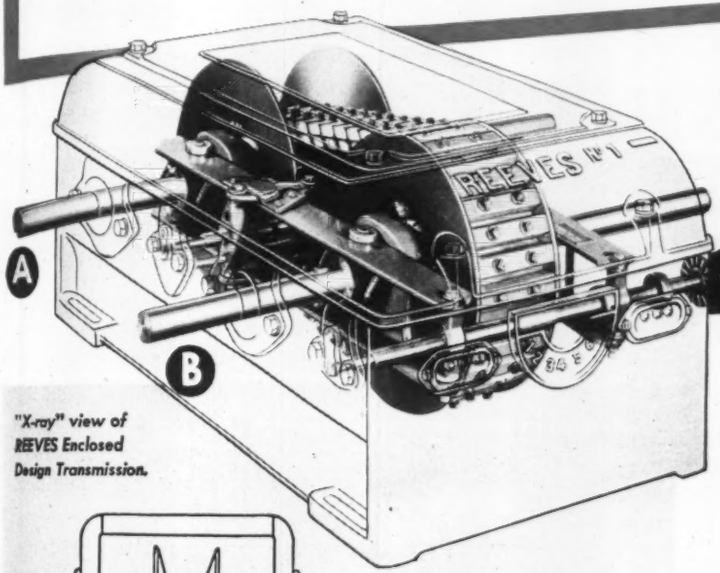
Fig. 7 shows records of the vibration of the supporting floor obtained when only one machine was operating (*a*) while rigidly secured to floor, and (*b*) while supported by rubber mountings. In this case the average amplitudes of floor movement obtained by calibrating the accelerometer records result in

$$Amplitude\ residue = \frac{.00042\ (resiliently\ mounted)}{.00282\ (rigidly\ mounted)} = 14.9\%$$

calculated transmissibility was 18 per cent. This accomplished all that was desired, and it may be remarked that more effective insulation could be prescribed but the cost would be greater.

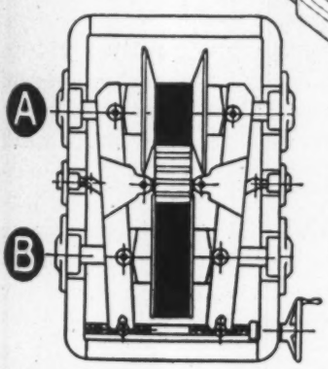
Fig. 8 is a reproduction of records of vibration obtained in a building carrying sensitive laboratory apparatus but being disturbed by a reciprocating machine. An insulated foundation for the apparatus was provided. Quantitative records were made,

See HOW THE REEVES TRANSMISSION PROVIDES COMPLETE SPEED ADJUSTABILITY . . .



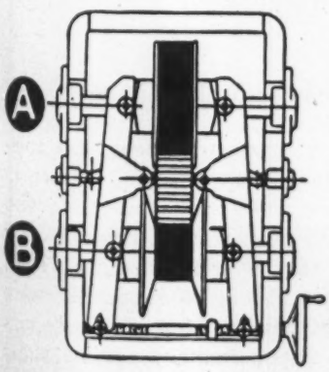
"X-ray" view of REEVES Enclosed Design Transmission.

"With the hundreds of REEVES Speed Control units we've installed on our machines, we have never had a complaint or occasion to ask for service," says well-known machinery builder.*



AT MINIMUM SPEED POSITION

On constant speed shaft "A," cone-faced discs and speed-changing levers are *farthest apart* while the V-belt runs at *smallest* diameter between the discs. On variable speed shaft "B" reverse is true and shaft runs at *minimum* speeds.



AT MAXIMUM SPEED POSITION

On constant speed shaft "A," cone-faced discs and speed-changing levers are *closest together* while the V-belt runs at *largest* diameter of the discs. On variable speed shaft "B" conditions are reversed and this shaft runs at *maximum* speed.

The entire speed range is covered smoothly, without steps or jumps, from one speed to another and while the driven machine is in operation. No interrupting production.

You can quickly see by these diagrams how the REEVES Variable Speed Transmission provides any driven machine with infinite speed adjustability.

Design is based on the proved and tested principle of a V-belt driving between two pairs of adjustable cone-faced discs mounted on parallel shafts. One shaft receives power at constant speed from motor, lineshaft, etc. The other, connected to the driven machine, transmits power at infinitely adjustable speeds above and below the speed of the constant speed shaft as the V-belt assumes different diameters of contacts against each set of discs.

Power is transmitted positively because of non-slipping, wedge-like action of the rugged REEVES endless cord V-belt. Equally important—any speed setting is maintained without fluctuation because *belt tension is automatically controlled at all driving diameters.* With REEVES speed adjustability, positive and accurate over full range, machines can be run at greatest efficiency under every changing condition.

Sizes from fractional to 87 h.p. Speed ratios from 2:1 through 16:1. Vertical and horizontal models. Manual, automatic or electric remote controls for speed changing. Write us.

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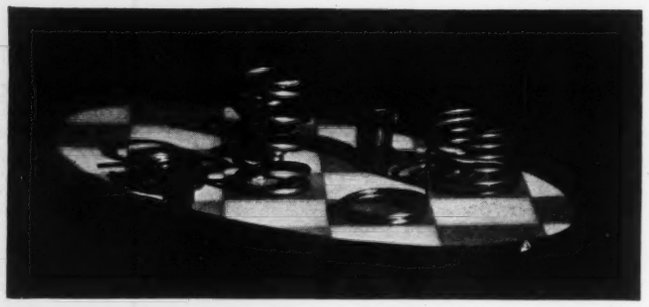
* Name on request.

REEVES *Accurate Variable* Speed Control



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Cincinnati Gears are made to order for your individual job requirements. They are a positive guarantee of "Production Insurance" . . . wherever good gears are needed.

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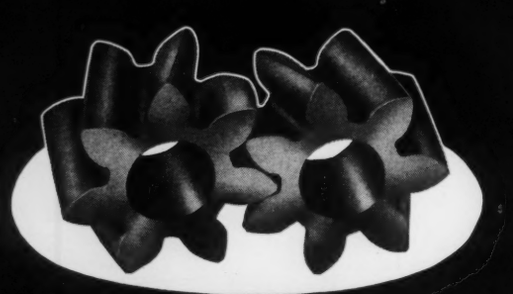

THE CINCINNATI GEAR COMPANY
"Gears . . . Good Gears Only"
1825 Reading Road • Cincinnati, Ohio

with the following result as to the average vertical amplitudes:

$$Amplitude\ residue = \frac{.000012\ (insulated\ unit)}{.00608\ (supporting\ floor)} = .19\%$$

The frequency ratio was 5.33:1 and the calculated transmissibility 3.54 per cent.

To enable the engineer to approximate the performance he may expect from rubber springs to be used for insulation of vibration encountered, the following information on the determination of the resonance frequency is included. The author is indebted to Drs. S. M. Cadwell and S. A. Black, also to Mr. C. M. Sloman, of United States Rubber Co. for their efforts and co-operation in obtaining essential data.

Determine Relation to Calculations

Standard mountings, 1¼-inch diameter by 1.09-inch effective rubber length, made of five standard mounting compounds, were used in laboratory tests to determine the relationship between actual and calculated resonance frequencies obtained by using rubber stressed both in shear and compression. In addition to the foregoing solid rubber mountings, a few tests were made on structural cellular rubber.

Essentially the experiments consisted of supporting, with the mountings under test, a weighted platform which was caused to vibrate by means of a double eccentric weight arrangement which produced vertical vibratory forces without comparable horizontals. Amplitudes of vibration were measured by means of a dial gage in contact with the platform; eccentric speeds were established by means of a strobotac; vibration velocities were obtained through a velocity meter. The eccentrics were driven from a variable speed motor. Testing speeds varied from about 250 to 1750 cycles per minute.

Mountings Give Equal Static Deflections

During the tests the number of mountings comprising a given rubber compound was chosen to give approximately the same static deflection with approximately the same weight as samples of other compounds stressed in the same manner. Thus, for the hardest compound, only four samples were used whereas sixteen samples of the softest compound were used to approximate the same static deflection.

Auxiliary tests were made employing the most generally used mounting compound (No. 5133, 40 durometer) stressed both in compression and shear. In these tests the resonance frequency was caused to vary over a fairly wide range to permit determination of the frequency factor (or the factor by which the *calculated* resonance frequency must

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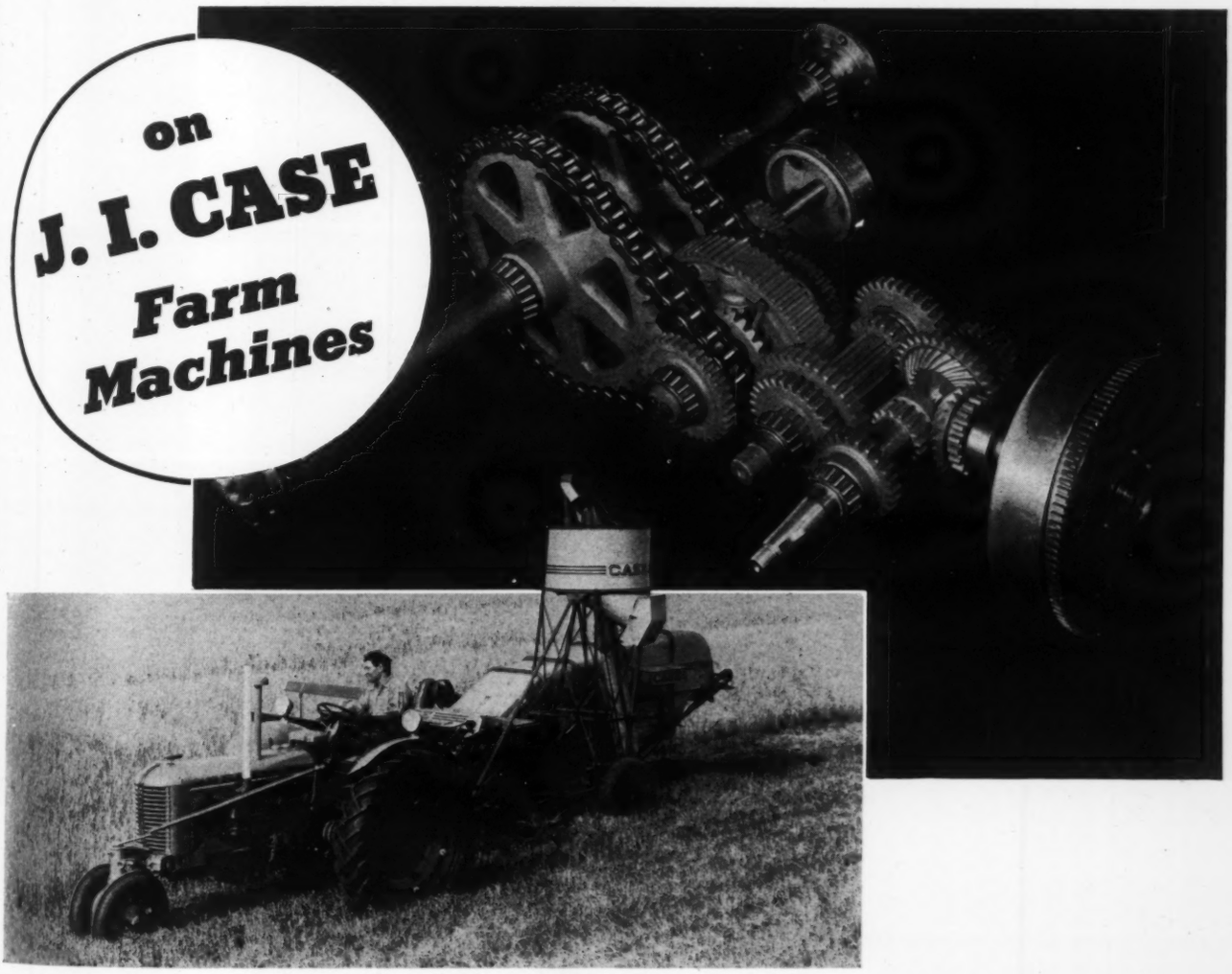

For the Centennial Jubilee Year, this famed farm machinery builder points full efforts toward meeting the "New need for farmpower that makes the most of limited manpower . . . that steps up the hourly capacity of implements and machines . . . that goes on and on without interruption for mechanical attention."

And to assure full power-delivery and longest life in service, Case builds the *extra* strength of tough-alloy Whitney Roller Chains into final tractor drives . . . and builds the smooth dependability of Whitney Conveyor Chains into other equipment like combines. So Whitney helps protect the Case guarantee of "Full Farmpower." And Whitney Chains will write the same guarantee into all the machines *you* build.

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Roller Chain & Sprockets, Silent Chain & Sprockets, Conveyor Chain & Sprockets, Roller Chain Flexible Couplings, Automatic Load Limiting Sprockets, Automatic Drive Tensioners, Woodruff Type Machine Keys and Cutters.

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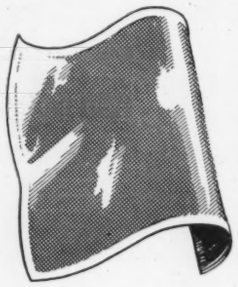

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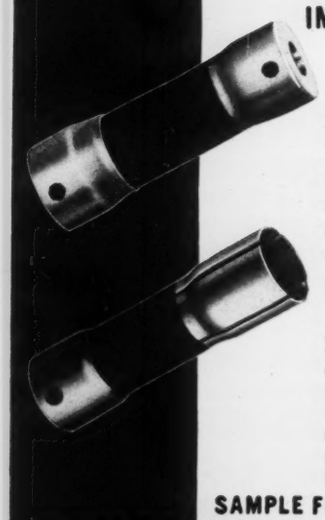

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Features rubber cushion, made with *exclusive* oil-resisting treatment. Gripped permanently by die-cast ends.

Custom-made in various degrees of flexibility, engineered to job. Splined sleeve or standard types. Made any length from 2-1/2" up. Bores 5/16", 3/8", 7/16" and 1/2". Amazingly simple construction. No parts to get out of order, become noisy, or need replacement. More than a half million in service.

SAMPLE FOR TESTING ON REQUEST

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MICHIGAN CITY, IND.

be multiplied to determine the *actual* resonance frequency).

In the charts, *Fig.* 9, the results of the foregoing tests are given. Compounds of 30, 40 and 50 durometer are used most extensively for rubber mountings. In the lower frequencies (up to about 600 cycles per minute), calculated static deflection may be used without correction except above 60 durometer.

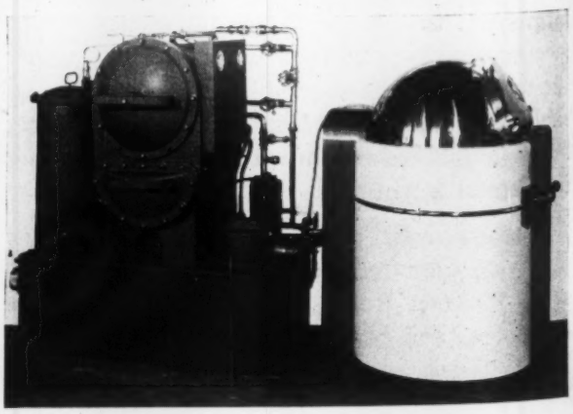
Amplitude at resonance is much smaller for the harder compounds than for the softer ones. The harder compounds are, however, almost never used because their cost for a given deflection is higher, and they are more susceptible to drift or permanent set. Cellular rubber can be deflected, statically, only about 10 per cent of its thickness but it can be operated closer to resonance than solid rubber of 30 and 40 durometer.

As with any other commodity, the life of rubber mountings depends entirely upon the abuse to which they may be subjected. When used under favorable conditions, mountings may be expected to function satisfactorily for at least six years. Records of much longer life exist. It is of course obvious that the longer the life requirement, the less must be the stress and abuse to which the mountings are subjected.

Utilizes V-Belt Drive

FOOLPROOF operation of a compact dry-cleaning unit requiring two speeds for a washer basket was initial problem in machine designed by Band Box Corp. Enclosed within a tank, the basket revolves in a cleaning solvent at a slow speed of 44 revolutions per minute and then at 800 revolutions per minute during the solvent recovery cycle.

Two speeds are provided by the gearmotor on a countershaft giving either 88½ or 1725 revolutions per minute. The reductions to 44 and 800 revolutions per minute are accomplished with a dual V-belt pulley drive. The belts are of the B type consisting of a number of segments which allow the belt to be enlarged or shortened without making any adjustments to the drive motor itself.



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AS APPLIED TO POTTER AND JOHNSTON LATHE

This Potter and Johnston Automatic Turret Lathe is equipped with a "LOGAN" Three Jaw Chuck and a Model "R" Rotating Type "LOGAN" Air Cylinder. The "LOGAN" Chuck combines extra strength and rigidity with extreme compactness and light weight. The double acting "LOGAN" Rotating Air Cylinder is designed to supply power efficiently and economically to all types of chucks required to be mounted on a revolving spindle. This heavy duty "LOGAN" Air Equipment assures positive gripping and rigid support of work. "LOGAN" Representatives and "LOGAN" Engineers will be glad to make recommendations on your chucking problems.

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Makers of Standardized Jig and Fixture Bushings

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Viewpoints

(*Concluded from Page* 92)

thermosetting resin adhesives, of either the phenol formaldehyde or urea formaldehyde types. Both of these are furnished as hot-setting and cold-setting materials. Hot-setting varieties are, in general, superior to the cold-setting in their water resistance and other mechanical properties. For the most part, plywood is bonded using hot-setting varieties, and the cold-setting types are used only where the application of heat is difficult.

While the use of synthetic resin adhesives prevents bacteria and fungus attack of the glue line, it does not exclude the possibility of such attack taking place in the wood. Attack of the wood may be delayed by the use of the new type synthetic resin finishes, or it may be eliminated by proper impregnation of the wood fibers with a synthetic resin material. Such impregnation may be accomplished with or without densifying the wood structure, the only reason for densification being to obtain an extremely strong material of relatively high density. In applications where the stresses are relatively low and where panel buckling is the design criteria, the impregnated undensified materials have the greatest strength-weight ratio because their lower density permits the use of thicker sheets and thereby raises the allowable buckling load. In applications where buckling cannot occur, and where the stresses are relatively high, the impregnated fully-densified materials are superior. At the present time, however, impregnated plywoods are not commercially available.

Fabrication of wood and plywood assemblies differs from that previously used in aircraft construction in two major respects: First, various processes have been developed for the manufacture of plywood in compound curved shapes and, in some of these processes, stiffeners and ribs are molded to the plywood at the same time. Second, the fabrication of large wood members, such as wing beams, by laminating, has in most cases replaced their fabrication in solid timbers, thereby permitting the use of smaller pieces of wood and closer inspection of possible internal flaws.

It should be pointed out that there is still question in some quarters as to whether the modern resin-bonded plywoods are equal to the metals in permanence of dimension and resistance to the elements.

—Geo. W. De Bell, *Plastics Research Engineer*
The Glenn L. Martin Co.

Correction

The article, "Combining Maximum Spring Deflection with Minimum Space," in the January issue continues from Page 59 to 126 instead of to 102 as erroneously stated. The article then concludes on Page 102. Also, the first term of the second member of Equation 9 should be inverted to read $\pi c/K^2$.

PERMIT USE OF HARDENED STEEL PARTS IN ARMAMENT MANUFACTURE WITHOUT PRODUCTION DELAYS

Many of the steel parts required in the manufacture of armaments must be heat treated to hardnesses of over 350 Brinell. Often these specifications apply to intricate shapes and combinations of thick and thin sections which are virtually impossible to quench without considerable warpage.

The answer has been to machine *after* heat treatment. KENNAMETAL, the steel-cutting carbide, machines parts up to 550 Brinell with speed and accuracy, allowing heat treatment to any practical degree of hardness before machining.

KENNAMETAL tools cost no more than ordinary carbide tools—see our new price schedule, effective Jan. 5, 1942.

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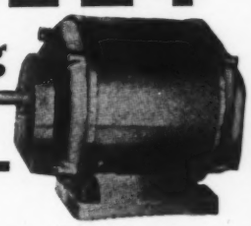
VALLEY
Ball-Bearing MOTORS



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DRIP PROOF—SPLASH DESIGN

Valley Ball-Bearing Motors are designed to meet operating conditions where hazards of liquids, chips etc., dropping into the motor, are involved. Motors are protected against this as well as against normal splash conditions.

. . . *because BETTER MOTOR DESIGN* has been the consistent aim of Valley Electric Corporation engineers throughout the years. The Valley Ball-Bearing Electric Motor of today offers definite buyer-appeal in efficiency and economy to the purchasers of your equipment. That is why prominent design engineers are incorporating Valley Ball-Bearing Motors in their plans.

Consider the importance of these five outstanding features when you order your next motor. (1) No Dead Spots. . . . (2) Efficient and Ventilated Winding. . . (3) 40° C. Maximum Temperature Rise. . . (4) Squirrel-Cage Welded Rotors. . . (5) Ball Bearings.

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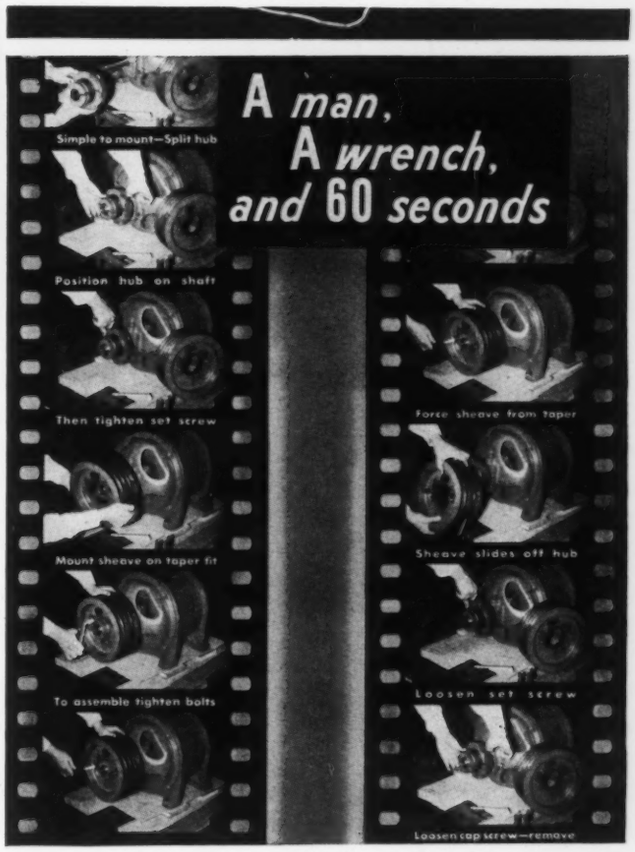
A man, A wrench, and 60 seconds
Simple to mount—Split hub
Position hub on shaft
Then tighten set screw
Mount sheave on taper fit
To assemble tighten bolts
Force sheave from taper
Sheave slides off hub
Loosen set screw
Loosen cap screw—remove

See how the Worthington Quick Detachable QD Sheave cuts installation time for attaching and detaching V-belt sheaves and eliminates the old hub-to-shaft problem of loose fits, tight fits, sledging, pressing, crow bars and wheel pullers with just A Man—A Wrench—and 60 Seconds.

The new Patented Quick Detachable QD Sheave design . . . the result of Worthington engineering research and development . . . is a departure from the age old hub principle. This new Worthington design incorporates a split hub that is positioned on the shaft with a single cap screw. The sheave rim is pulled up on a tapered fit with the hub by pull-up bolts, providing a positive press fit assembly or a tapered friction drive fit. Designed originally for modern short stub shaft applications to minimize bearing loads and shaft stresses, yet the QD Sheave may be applied to any existing type of driver or driven unit.

Just "A Man—A Wrench—and 60 Seconds" means much to industry in these days of maximum production with no time to spare for repairs.

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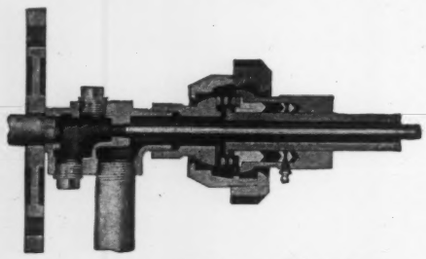

Type
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With Syphon
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Size, ½ to 3", Inclusive

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LOWER COST POWER CONSUMPTION

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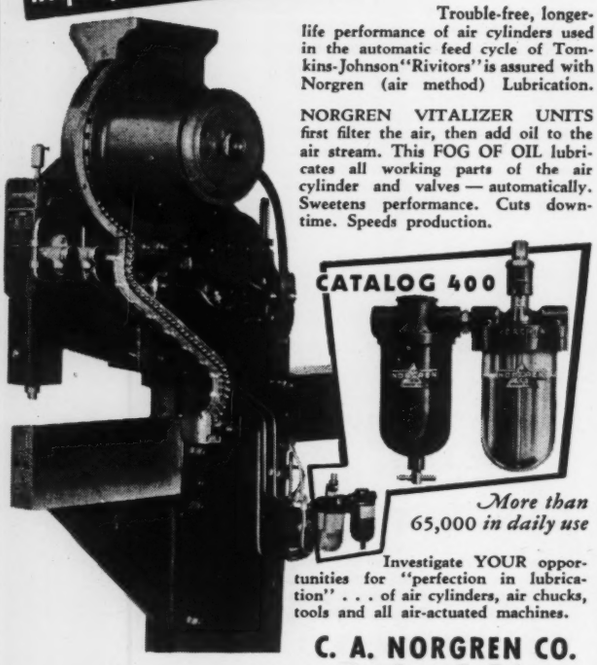
helps speed 1600 "joint" operations per hour



Trouble-free, longer-life performance of air cylinders used in the automatic feed cycle of Tomkins-Johnson "Rivitors" is assured with Norgren (air method) Lubrication.

NORGREN VITALIZER UNITS first filter the air, then add oil to the air stream. This FOG OF OIL lubricates all working parts of the air cylinder and valves — automatically. Sweetens performance. Cuts down-time. Speeds production.

More than
65,000 *in daily use*

Investigate YOUR opportunities for "perfection in lubrication" . . . of air cylinders, air chucks, tools and all air-actuated machines.

C. A. NORGREN CO.
211 Santa Fe Drive
DENVER, COLORADO

Designing Short Beams

(*Concluded from Page 72*)

By inspection, V_a is also greater than V_e so that Equation s need not be considered. It can also be shown that V_d is greater than V_b. Governing value of V will be determined by equation r, t or v. The deciding value will depend upon the relative values of M/Q and the relative magnitudes of the dimensions. By equating the above values of V to the allowable value $kS_w{}^2$, the required section modulus is one of the following:

$$\frac{I}{c} = \frac{M}{S_w}\sqrt{\frac{1}{R_b} - \frac{R_t{}^2}{R_b} + R_d{}^2 - \frac{4}{3}\left(\frac{M}{Qd}\right)^2} \quad \text{(6a)}$$

$$\frac{I}{c} = \frac{M}{S_w} \quad \text{(6b)}$$

$$\frac{I}{c} = \frac{M}{S_w}\sqrt{\frac{3}{16}}\left(\frac{Qd}{M}\right)\left(\frac{1}{R_b} - \frac{R_t{}^2}{R_b} + R_b R_d{}^2\right)^2 \quad \text{(6c)}$$

where $R_b = b_1/b$, $R_d = d_1/d$.

The section modulus which governs in Equations 6 depends upon the load ratio $M/(Qd)$ and the dimension ratios R_b and R_d. An examination of tables for standard I-beams shows that there is little variation in R_b and R_d values and a good approximation is $R_b = .1$ and $R_d = .9$. Using these values, Equations 6 become

$$\frac{I}{c} = \frac{M}{S_w}\sqrt{2.71 - \frac{4}{3}\left(\frac{M}{Qd}\right)^2} \quad \text{(7a)}$$

$$\frac{I}{c} = \frac{M}{S_w} \quad \text{(7b)}$$

$$\frac{I}{c} = \frac{M}{S_w}\left(.856\,\frac{Qd}{M}\right) \quad \text{(7c)}$$

The equation which determines the section modulus value is controlled by the type of beam and loading. Cases considered in *Figs.* 2 to 8 are shown similarly in *Figs.* 9 to 12 for I-beam sections. Equations for the section modulus, as determined by Equations 7, are also shown in these figures. The section modulus for a varying depth-length ratio again shows the importance of considering the combined stress effect.

Other types of cross section, supports and loading may be considered in a similar manner. If the shear and moment are not maximum at the same section, however, it will be necessary to introduce another variable x to represent the distance along the beam.

CORROSION process for producing metal powders, developed by John Wulff of M.I.T. can be applied to any alloy which can be heat treated. The process depends upon the difference in potential between grain and grain boundary, the size of the resulting powder being dependent upon the grain size before corrosion. Chrome-nickel steel and nickel-iron alloy have been powdered .

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Speedier deliveries now, because of Ruthman's enlarged manufacturing facilities.

RUTHMAN GUSHER COOLANT PUMPS

Model P3

P3 is available in external right or left discharge models, flange-mounted and immersed models.

Simple in construction—no packing nuts—no foot or relief valves. Built-in motor, sturdy vertical shaft on ball bearings, double suction intake giving balanced impeller . . . these and other famous time-saving Gusher features help *SPEED* your jobs.

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METALLIC BELLOWS
FOR AUTOMATIC HEAT CONTROL

We manufacture bellows and bellows assemblies ready for installation in steam traps, relief valves, temperature regulators, pressure regulators, air valves, and other automatic temperature and pressure controls. Complete engineering service.

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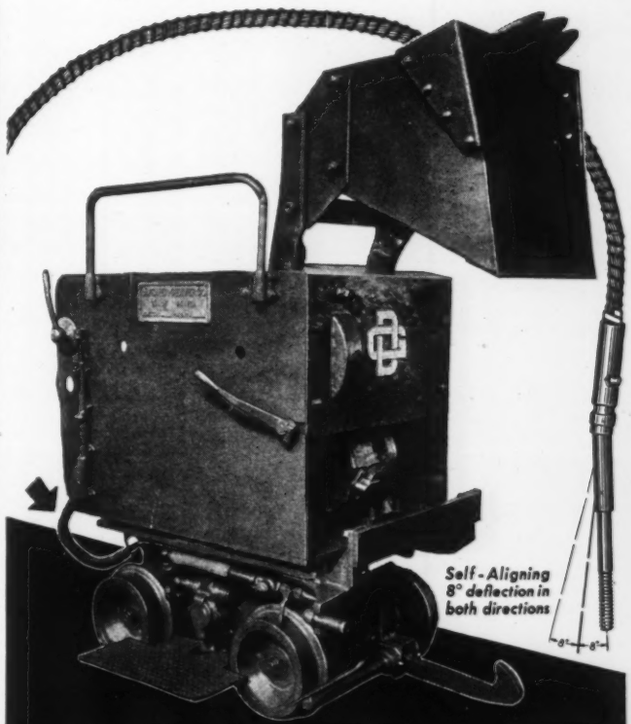

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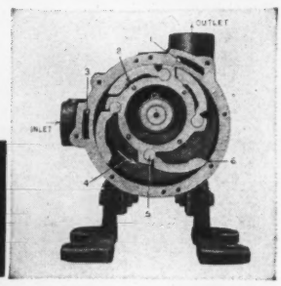
VACUUM PUMPS

also used as pressure blowers, gas boosters, and air motors

THEY TAKE UP THEIR OWN WEAR



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Business and Sales Briefs

GOVERNMENT contractors and sub-contractors can obtain confidential expert advice from The Frederick Post Co., Box 803, Chicago, on a time-saving method of reproducing drawings required under government contracts. With any request made for this information, it is asked by the company that inquirers specifically state whether contracts are for the Army, Navy, Air Corps or whatever other governmental department is involved. All requests must be made on company letterhead, signed by an officer of the company.

♦

For the past twelve years associated with Chicago Vitreous Enamel Product Co., Cicero, Ill., Dana Chase has been appointed general sales manager. He was formerly assistant to the vice president and general manager.

♦

Resignation of J. D. Colyer as director and vice president in charge of sales, Wolverine Tube Co., Detroit, has been announced. Supervision of all sales will be under direction of Otto Klopsch, vice president and general manager, with Robert Moody as special assistant.

♦

Dean Rollans has been elected vice president in charge of sales, Wickwire Spencer Steel Co., New York. Mr. Rollans joined the company in 1928 as wire rope sales representative in Tulsa.

♦

With headquarters in the Grant building, Pittsburgh, Walter E. Bisler has been appointed Pittsburgh district sales manager of Pomona Pump Co. He was previously sales engineer of the Combustion Engineering Co., Pittsburgh.

♦

Erie Bolt & Nut Co., Erie, Pa., has opened up a new branch sales office at Room 616, Williamson building, Cleveland, with William T. McKelvey as district manager in charge. His territory will include the state of Ohio.

♦

Formerly associated with Republic Steel Corp., Cleveland, James E. Holmes has been appointed assistant manager of tubular sales, Youngstown Sheet & Tube Co., Youngstown, O.

♦

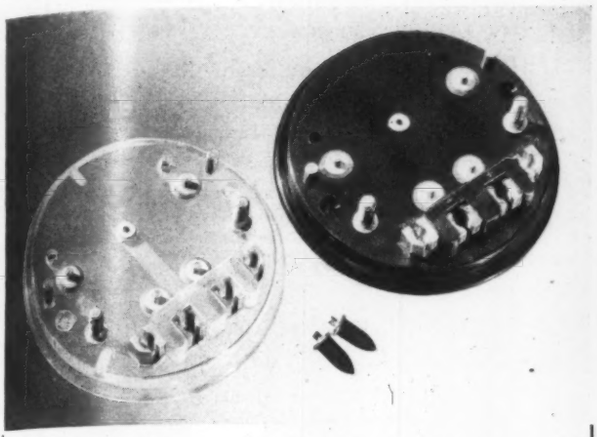
Previously Los Angeles sales manager of McKenna Metals Co., W. L. Kennicott is now located at the main office and factory of the company at Latrobe, Pa., in the management of sales and engineering.

♦

With the organization since it was founded in 1914, George L. Meyer, manager, Steward Die Casting division, Stewart-Warner Corp., Chicago, has been elected to the position of vice president. Joseph C. Elliff, assistant general sales manager, has also been elevated to vice president.

♦

Five months ahead of schedule, the Chicago Defense plant of Revere Copper & Brass Inc., New York, is already in partial operation. The ground



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1941 INDEX

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A limited supply of the 1940 index still is available without cost to readers as long as they last.

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Penton Building Cleveland, Ohio

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Speed and more speed—that's the tempo of this Nation's "all-out" industrial effort — it assures our winning the war and the peace. To secure this vital speed, material for fabrication must consistently meet rigid specifications to make trouble-free production certain. In defense plants, where CMP cold rolled strip steel is "on the job", accuracy and precision is duplicated in coil after coil—uniformity of physical properties and always rolled to close tolerances. It provides "extras" that mean more feet per pound and thus more finished parts per hundred pounds—an important contribution to faster and lower cost wartime production and equally valuable for peacetime operations.

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for this plant was broken last summer, and everything is being done to reach peak production in this and other mills of the company. The plant is being built solely to produce cartridge cups, bullet jackets and ordnance brass.

♦

Appointment as deputy to the chief of the rubber and rubber products division of the former OPM (a section which probably will be continued) of A. L. Freedlander, president and general manager of The Dayton Rubber Mfg. Co., Dayton, O., has been announced. Mr. Freedlander has been in the rubber industry for twenty-eight years, the last twenty-two of which were in the service of the Dayton Rubber company.

♦

Celluloid Corp. and the Celanese Corp. of America were recently merged and are now known under the name of Celanese Celluloid Corp., 180 Madison avenue, New York.

♦

For the past year sales manager, air conditioning and commercial refrigeration department, General Electric Co., Bloomfield, N. J., Elliott Harrington has been named manager of sales, induction motor section of the company's motor division at Schenectady, N. Y.

♦

Kropp Forge Co., Chicago, manufacturers of steam hammer, drop and upset forgings, has been awarded the United States Navy ordnance flag and the Navy's blue "E" pennant. Approximately 96 per cent of its forging capacity has been devoted to national defense.

♦

Moving of its Detroit office development and research division to 8-217, General Motors building, has been announced by International Nickel Co., New York.

♦

Gray Iron Founders' Society Inc., has moved its Washington office to Apartment 400, 2633 Sixteenth street, Northwest.

♦

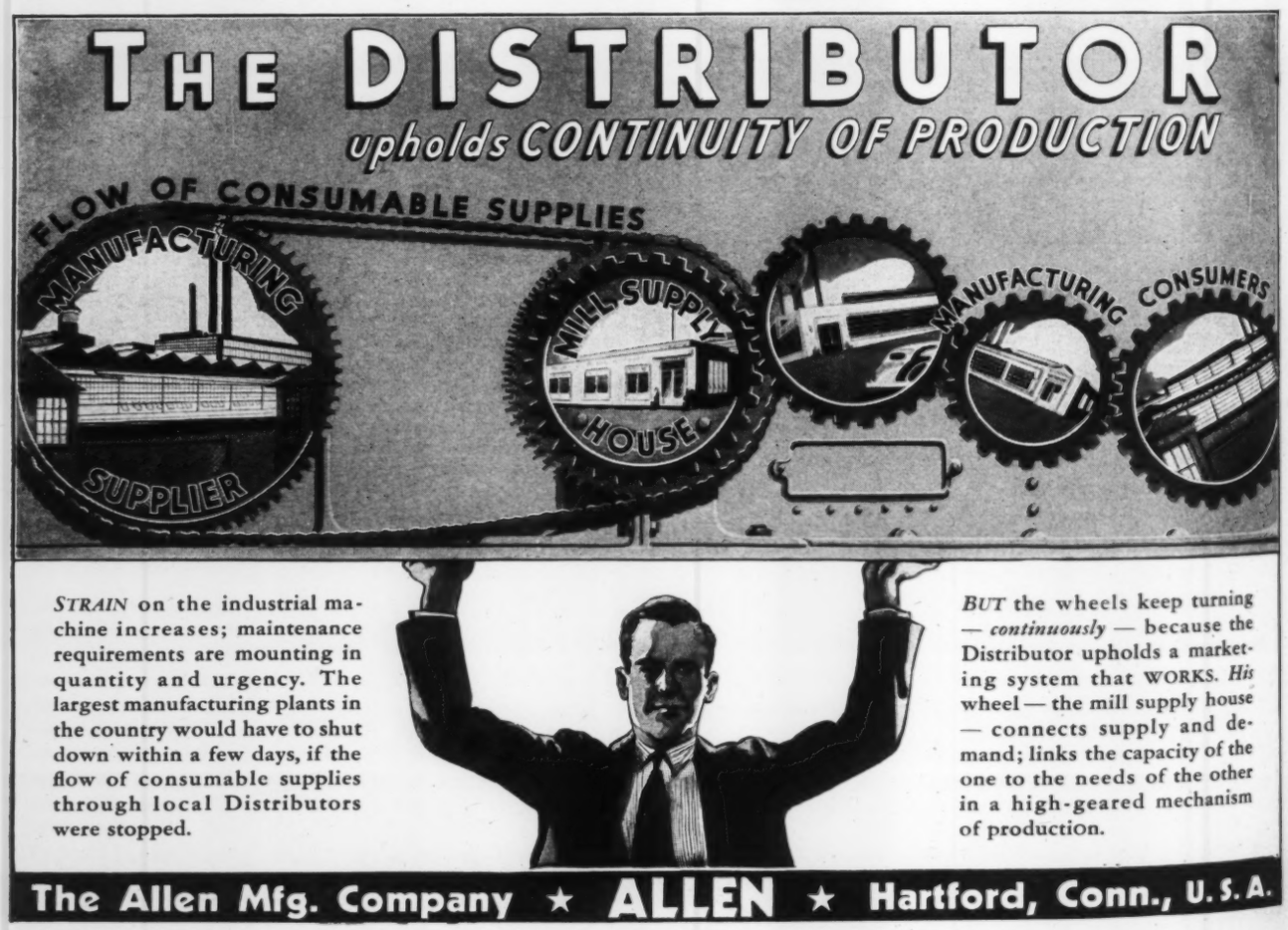
Several new representatives have been appointed by Trico Fuse Mfg. Co., Milwaukee. These are: Pacific Industrial Products Co., Ninth and Harrison streets, Oakland, Calif., covering the northern part of California; H. H. Van Luven, 307-309 East Third street, Los Angeles, covering the southern part of California, all of Arizona and Nevada; Albert S. Knight Co., 3006 Western avenue, Seattle, Wash., covering Washington, Oregon, northern part of Idaho and the western part of Montana; and M. F. Holland Co., Lee and Sharp streets, Baltimore, covering the state of Maryland.

♦

In addition to his new duties as manager of the wiring device section of General Electric's appliance and merchandise department, T. D. Foster will retain his present position as manager of the accessory equipment section. J. D. Dallam, formerly manager of this wiring section, has retired after forty years of service.

♦

International Nickel Co., New York, has announced the appointment of three new assistants to J. F. McNamara, monel sales manager. They are: W. J. Calnan, H. D. Tietz, and E. A. Turner. H. E. Searle has been transferred to the nickel sales department under R. L. Suhl, sales manager.



STRAIN on the industrial machine increases; maintenance requirements are mounting in quantity and urgency. The largest manufacturing plants in the country would have to shut down within a few days, if the flow of consumable supplies through local Distributors were stopped.

BUT the wheels keep turning — *continuously* — because the Distributor upholds a marketing system that WORKS. *His* wheel — the mill supply house — connects supply and demand; links the capacity of the one to the needs of the other in a high-geared mechanism of production.

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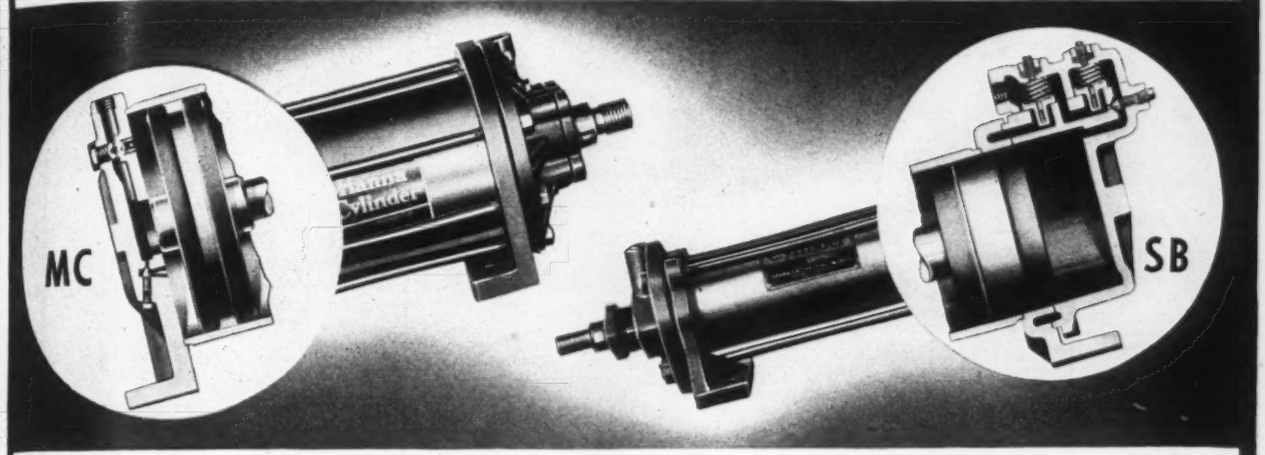
If your cylinders need a Cushion...
be sure **IT'S THE RIGHT TYPE FOR THE JOB!**



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